OBITUARY NOTICES OF ASTRONOMERS

—

J. DUNKIN

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OBITUARY NOTICES

OF

ASTRONOMERS

...

Fellows and Associates of the Royal Astronomical Society

WRITTEN CHIEFLY FOR THE ANNUAL REPORTS

OF THE COUNC

23422

BY

EDWIN DUNKIN, F.R.S., F.R.A.S.

OF THE ROYAL OBSERVATORY, GREENWICH

HONORARY SECRETARY OF THE ROYAL ASTRONOMICAL SOCIETY 1871–1877

WILLIAMS & NORGATE

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PREFACE.

DURING the six years that the Author of these brief necrological notices had the privilege of serving as one of the honorary secretaries of the Royal Astronomical Society, one of the most congenial occupations of his leisure hours was the yearly arrangement of the Council's Annual Report of the progress of the Society and of astronomy. In compiling these Reports, the Council endeavour to obtain notices of the scientific labours of all deceased Fellows and Associates, whose deaths have occurred during the preceding year, from writers personally acquainted with them, or with their works. In carrying out the wishes of the Council, the author was ably supported by some of his most valued friends, Fellows of the Society, who at various times willingly assisted him in this section of the Report. It occasionally happened, however, that writers could not be found even to prepare a short abstract of the scientific life of a deceased Fellow or Associate, especially of the latter. When this was the case, the author himself usually undertook, if possible, to

complete the list of obituary notices, with memoirs derived from the best sources accessible to him, the most important of which are included in the following pages.

Of the twenty-four biographical sketches comprising this work, nineteen were contributed to the Council's Reports from 1872 to 1878. The memoirs of Professors Heis, von Littrow, and Santini, were, however, first published in the *Observatory, a Monthly Review of Astronomy*, and afterwards partly rewritten for the Annual Report. The memoir of M. Le Verrier is also a considerably enlarged edition of that inserted in the *Observatory* for October 1877. The notices of the astronomical labours of Sir John Herschel and Sir William Herschel were compiled in 1865 and 1867 for the *Leisure Hour*; but for the present work they have been rearranged and rewritten, with very considerable additions, and they have now little in common with the original articles. The memoirs of the Rev. Robert Main and Sir Andrew Waugh were prepared specially for these pages. All the other notices have been thoroughly revised.

E. D.

KENWYN, KIDBROOKE PARK ROAD, BLACKHEATH:
March 1879.

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OBITUARY NOTICES
OF
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REAR-ADMIRAL A. B. BECHER.

1796–1876.

REAR-ADMIRAL ALEXANDER BRIDPORT BECHER was the son of Captain A. Becher, R.N., an officer of high scientific attainments. He was born in the year 1796. He entered the Royal Naval College in 1810, and in November 1812 joined the 'Barham,' 74, Captain Spanger, with whom he served as master's mate. The ship was attached to the Channel Fleet, then engaged in the blockade of Brest, from which it was detached to take a large convoy of ships to and from the West Indies. After serving a short time in the 'Cordelia,' a 10-gun brig, in the Channel, he joined Commodore Owen for active service on the Lakes of Canada during the American War; but on peace taking place soon afterwards, he was transferred to the surveying party under the command of Captain W. F. Owen, brother of the Commodore. This officer was in 1815 commissioned to survey the Canadian

Lakes and the River St. Lawrence. Young Becher entered heartily into this work, for which he was exactly suited, the survey having been carried on by a large party afloat in summer, and on the ice in winter; and he has remarked that 'he took his full share of the ice work, and had as many duckings from breaking through the ice as any one of the party.' In 1818 he joined the 'Superb,' 74, at Plymouth, and in September of that year the 'Leven,' Captain Bartholomew, with whom he spent twenty months on scientific service in the Atlantic, determining the longitude of Funchal, rock hunting, and in surveying the Azores, a part of the African coast, and some of the Cape Verd Islands. In 1820 he was appointed to the 'Conway,' 26, Captain Basil Hall, on the South American station; and in May 1822 he received his first promotion, as Lieutenant. Between March and December 1839, he served as First Lieutenant in the 'Fairy,' surveying vessel, which in the following year foundered during a severe gale in the North Sea, with the loss of Captain Hewett and all his crew. He was made a Commander in 1841; and his last service afloat was undertaken in 1848, to qualify himself for promotion to the next step of rank. Captain Becher thus completed his necessary period of active service as Commander of a surveying vessel on the coast of Scotland. In 1856 he attained the rank of Captain on the Reserved list, and about a year before his death that of Retired Rear-Admiral.

In 1837 Lieutenant Becher communicated to the Royal Astronomical Society a description of his well-known pendulum artificial horizon, to be attached to

a sextant or quadrant for the purpose of observing altitudes by day or night at sea. The special object of the invention was to provide a means of making accurate sextant observations when the real horizon is invisible either from haze, fog, or other cause. This contrivance consists of a small pendulum carrying an arm nearly at right angles to it, leading to the point of suspension, the whole resting on an agate point. A vane, perpendicular to the plane of the pendulum and arm, is placed at the end of the latter, and has its upper edge cut horizontal, which forms the visible horizon. This apparatus is placed in a tube laid in the direction of the telescope, and attached to the sextant beyond the horizon glass. The vibrations of the pendulum are diminished by placing it in a small cistern containing oil, which is so contrived that on turning up the face of the sextant to read off, the oil runs into another cistern. A sextant fitted with this pendulum apparatus of Lieutenant Becher requires careful manipulation, but when used by competent observers it has been proved to be a valuable aid to the naval officer. The extra attention required in the adjustment of this instrument has, however, prevented it from becoming popular in the service; but the Admiralty acknowledged the ingenuity of the inventor by granting him a moderate pecuniary reward.

In 1823, soon after his return from the South American station, an opportunity was afforded him of employment at the Hydrographic Office. Owing to the recent death of the Hydrographer, an officer was required to arrange and methodise, for easy

reference, all the numerous and varied documents preserved in that office, consisting of charts, maps, and plans of every kind, both printed and in manuscript. This entailed the compilation of a general and alphabetical catalogue, with a methodical geographical arrangement of the whole of the papers. For such a work Lieutenant Becher, who happened to be visiting the Admiralty with the object of obtaining an appointment in another ship, appeared to be just the person required; and as he had been accustomed to maritime surveying, and was well acquainted with the construction of charts, this duty was offered to him by the new Hydrographer. He very gladly accepted the laborious task; and his youth and vigour, together with a natural love for the seaman's chart, and a zeal that would not yield to any amount of work, carried him on to the completion of the catalogue, which required three years for its performance. The number of separate entries exceeded 50,000.

Lieutenant Becher's experience of marine surveying, and his general knowledge of hydrographic work, increased in no small degree by his recent duties, led to his permanent appointment as assistant in the Hydrographic Office, in which he remained till his retirement on superannuation in 1865. Twice during this long service he was permitted to go afloat to qualify for rank; but his Admiralty employment was, in each case, kept open for him till his return. While holding the official rank of Chief Assistant to the Hydrographer, Captain Becher also acted as Secretary to the Board of Visitors of the Royal Observatory. At the annual visitation on the first Saturday in June

of each year, it was his invariable custom to give an official character to his journey from the Admiralty, and many will recollect the pleasant hour passed in his company from Whitehall to Greenwich in the Admiralty barge. He became a Fellow of the Royal Astronomical Society in 1830, and has served on the Council.

Captain Becher took a great personal interest in the success of the *Nautical Magazine*, of which he was the editor from its commencement in 1832 to 1871. It was his chief endeavour to make it a favourite among nautical men, in which they might find hydrographical notices of the discoveries of rocks and shoals, the establishment of lighthouses or buoys, and of all matters of interest relating to the Navy or the Mercantile Marine. It was, indeed, a child of his own. He was its guiding spirit during the forty years of his editorship, and he succeeded in obtaining for it a considerable professional reputation, its pages having been always open to the advocacy of any cause which had for its object the promotion of the interests of naval officers or the amelioration of the condition of our seamen. Many of the most important papers in the magazine were from his own pen, including translations of foreign hydrographical notices. Captain Becher was often occupied in his leisure hours with other literary work; and in his *Landfall of Columbus* he has apparently succeeded, after much labour, in tracing the actual progress of Columbus among the islands discovered by that great navigator on his way to Cuba.

During the last few years of Admiral Becher's

life, failing health compelled him to relinquish all public work; and he lived in retirement, respected by the profession as a kind friend, a zealous and hard-working officer, and a valuable public servant. His promotion to the rank of Rear-Admiral was gratifying to him in his old age, though he did not long enjoy the honour. He died at his residence in London on February 15, 1876, in his eightieth year. His daughter is the wife of Dr. Ellicott, Lord Bishop of Gloucester and Bristol.[1]

[1] The author is indebted to Mrs. Ellicott for her courtesy in forwarding to him for perusal some autobiographical memoranda written by Admiral Becher after his retirement from the Hydrographic Office.

PROFESSOR H. L. D'ARREST.

1822–1875.

HEINRICH LOUIS D'ARREST was born at Berlin on August 12, 1822. His family is of French extraction, his ancestors having been among the Huguenot refugees who settled in Germany after the Revocation of the Edict of Nantes in 1685. In early life his tastes and inclination led him to the study of mathematics, which was followed by its practical application in astronomical calculations and observation even while still a student at the University of Berlin. His name was first brought into notice outside his native city by an independent discovery of Mauvais' second Comet, which he detected on July 9, 1844, two days after it was first seen at Paris. At this time he had attained considerable skill as an observer, as is shown by the fact that while immediately informing Professor Encke of the discovery, he on the same night also furnished a position of the comet determined from a good series of observations. Although anticipated on this occasion, he had the good fortune to detect another comet on December 28 of the same year. Continuing his cometary investigations, D'Arrest communicated to Professor Schumacher, in September 1845, a very careful discussion of the observations of Colla's Comet, which had been first detected by the

naked eye in the first week of the preceding June. Soon after this D'Arrest was appointed an assistant at the Observatory of Berlin, then under the direction of Professor Encke. In 1848 he accepted the office of Observer at the Leipzig Observatory, and shortly afterwards that of Professor of Mathematics and Astronomy in the University. Here he remained till 1857, when he received the appointment of Director of the new Observatory in connection with the University of Copenhagen, in which his first duty was the superintendence of the construction and instrumental equipment of the new establishment.

During D'Arrest's residence at Leipzig, he discovered the interesting periodical comet which bears his name, new osculating elements of which have been computed by M. Leveau, of Paris. D'Arrest also during this time communicated to the *Astronomische Nachrichten* and the *Monthly Notices* numerous elements and ephemerides of the minor planets and comets calculated by himself, and in 1851 he published a valuable paper on the general system of the minor planets. Soon after his appointment to the Leipzig Observatory he commenced his important series of observations of the positions of the nebulæ. These Leipzig observations appeared, as a first instalment of nebulæ results, in his work published in 1856, entitled, *Resultate aus Beobachtungen der Nebelflecken und Sternhaufen.* The merits of this, and of his still more important work on the observation of the nebulæ, made subsequently at the Observatory of Copenhagen, entitled *Siderum Nebulosorum Observationes Havnienses*, were fully considered by Professor

Adams in his address delivered on presenting the gold medal of the Royal Astronomical Society to Professor D'Arrest at the anniversary meeting held in February 1875; and, for this reason, there is no need for us to dwell upon them here, except to remark that, had these works been his only productions, they would alone be a sufficient memorial of the observational energy displayed by him both at Leipzig and Copenhagen. From the beginning to the end of his career D'Arrest may truly be classed as one of our most active observing astronomers; in proof of which a glance at his numerous contributions on various astronomical subjects, inserted in the *Astronomische Nachrichten*, and in other scientific serials, is a sufficient testimony. This activity and devotion to astronomical research continued to the end of his life; for even in the number of the *Astronomische Nachrichten* which records his death, some valuable remarks by him on some newly discovered objects exhibiting Star-spectra similar to Secchi's third and fourth types are also inserted. The Royal Society's Scientific Catalogue contains the titles of 123 separate papers by D'Arrest published before the end of 1873.

D'Arrest was the discoverer of one minor planet, *Freia*, in addition to several comets. Before the systematic observation of the nebulæ occupied so much of his time, he did good service to astronomy as the calculator of the elements of the orbits of the comets of Colla, Biela, Brorsen (second), Hind (second), Colla (second), Miss Mitchell, and others. He also published elements of the orbits of various planets, among others, of *Astræa*, *Iris*, *Flora*, and *Hygeia*,

soon after their discovery. He was indeed at this time one of the most energetic of the many young German astronomers who undertook the calculation of elements and ephemerides of newly discovered planets and comets, a necessary and important duty attached to our science, which is still so successfully encouraged at the present time in Germany by Dr. Foerster and Dr. Tietjen, who are the able superintendents of the calculations of the *Berliner Jahrbuch.*

As a conscientious and skilful teacher, Professor D'Arrest was popular among those who came to him for instruction. Whenever he detected real abilities in his pupils, with a never-failing energy he afterwards helped and assisted them in their studies, not forgetting at the same time that he was himself still a student, and that when in his thirty-sixth year he commenced the study of a foreign language which he perfectly mastered. He was indeed naturally endowed with superior abilities, which he constantly and progressively developed by the most diligent study. His knowledge of astronomical literature was very extensive; and he was also a good geometer, which is clearly manifested in several of his minor works. His intercourse with his father-in-law, the celebrated geometer, Möbius, of Leipzig, may possibly have influenced him in this branch of mathematics. But the inclinations and talents of Professor D'Arrest were more particularly directed to a class of scientific research in which conjectural reasoning was the main point of investigation, as well as to those observations in which great technical knowledge was not so much

required as the power of observing phenomena properly and correctly, and afterwards giving an accurate interpretation of what had been seen. Acting in this spirit, Professor D'Arrest employed much of his time in investigating the nature of the composition of the heavenly bodies, and particularly of the nebulæ; and this subject, of late years, was the main study and object of his life, leading him to undertake a valuable series of spectroscopic observations of the nebulæ, a full discussion of which, giving the results obtained, was published at Copenhagen in 1872.

Professor D'Arrest, during the latter years of his life, was subject to an occasional nervous prostration, caused probably by the gradual progress of the organic disease which ultimately terminated his life. It has been remarked that he suffered from a hypochondriasis which increased year after year. His death took place suddenly, from disease of the heart, on June 14, 1875, before he had completed the fifty-third year of his age.

Professor D'Arrest was a member of several scientific societies, including the Societies of Sciences of Denmark and Sweden, and the Academies of Sciences of St. Petersburg and Munich. He was elected an Associate of the Royal Astronomical Society on May 12, 1848. He was also a Knight of the Danish Order of the Dannebrog.

In addition to the numerous papers contributed to astronomical science inserted in the *Astronomische Nachrichten* and *Monthly Notices*, Professor D'Arrest was also the author of the following more elaborate works :—

Ueber das System der kleinen Planeten zwischen Mars und Jupiter. 1851.

Resultate aus Beobachtungen der Nebelflecken und Sternhaufen. 1856.

Instrumentum magnum aequatorium in Specula Universitatis Havniensis nuper erectum. 1861.

Telescopisk Undersögelse af Egnen omkring det Sted pad Himlen, hoor Tychos nye Stjerne har vist sig 1572–1574. 1864.

Siderum Nebulosorum Observationes Havnienses. 1867.

Undersögelse over de nebulose Stjerner i Henseende til deres spektralanalytiske Egenskaber. 1872.

CHARLES E. DELAUNAY.

1816–1872.

WHEN the intelligence reached England that the great French astronomer, M. Delaunay, had lost his life by the upsetting of a pleasure-boat near Cherbourg, a deep and general regret was felt by all classes of astronomers, and especially by the Fellows of the Royal Astronomical Society, who had little more than two years previously cordially welcomed his presence among them at the anniversary meeting. Shocked at the time, as we all were, by the suddenness of the calamity which deprived us of the services of so distinguished an astronomer, one can scarcely even at present realise the extent of the permanent loss which has fallen upon our science by his melancholy and premature death.

CHARLES EUGÈNE DELAUNAY was born at Lusigny, in the department of the Aube, on April 9, 1816, his father being a teacher of mathematics in that town. In 1818 the family removed to Ramerupt, in the same department, where he was placed in the public elementary school. To the end of his life M. Delaunay always considered Ramerupt as his home, where many of his relatives continued to reside. His father, who was a man of extensive knowledge, assisted him in his private studies, and

this helped to develop his natural talent. In 1826, when ten years of age, Delaunay was placed under the care of his great uncle, M. Joseph Cornet, a joiner at Troyes, so that he might have the advantage of attending the classes at a superior school in that town. Here he passed most of his leisure time in the workshop of his relative, constructing small models of machines and wheels in wood.

At the beginning of the year 1828 Delaunay became a pensioner in the College of Troyes. In this establishment he remained five years, and on leaving in 1833 he received the chief prize for special mathematics. His education was continued in the preparatory school of M. Bourdon, in Paris, where he had the opportunity of attending the higher mathematical course at the Lycée Charlemagne. On October 29, 1834, he was admitted into the École Polytechnique, being the tenth on the list in order of merit. At the end of the first year of his studies he was classed second by the examiners; and on October 18, 1836, he left the school, the first student of his year, having highly distinguished himself in the examination, which gained for him the prize given by the Academy of Sciences to the head pupil leaving the École Polytechnique. M. Delaunay was the first recipient of this prize, which was founded by the widow of La Place, consisting of a complete collection of the works of that illustrious mathematician.

The brilliant *sortie* of Delaunay from the École Polytechnique attracted the attention of M. Arago, one of his examiners, which led him to offer to the young mathematician the office of assistant-astronomer at

the Observatory of Paris. Through the influence, however, of M. Savary, who considered that the talents of so successful a student pointed to a higher position than that of an assistant to Arago, Delaunay preferred to enter the Écoles des Mines, which he joined on November 25, 1836. While here his vacation reports and journals on the coal-seams in the valley of St. Etienne and Creusot, as well as those on the principal iron and steel works of France, gave a remarkable evidence of that clearness of thought and skill in theoretical speculations, which have been so marked in all his subsequent investigations. When still a student at the École des Mines, his former masters, at the École Polytechnique, having full confidence in the originality and power of his mathematical knowledge, proposed his appointment as teacher of geodesy in that school. Though Delaunay was willing to accept this advantageous offer, certain objections were made by the managers in consequence of the anomaly of a student of one school holding a tutorial position in the other. The council of the École des Mines, at the head of which was M. Cordier, appreciating the great talents of young Delaunay, obtained, however, a special sanction for him to accept the office. He thus obtained the position of a teacher, and afterwards of a professor, in the school in which he had so lately distinguished himself. At a subsequent period he was also appointed a professor in the École des Mines.

It was part of the curriculum of the École des Mines to give a preparatory course of instruction for the benefit of engineers, both for those attached to

the Corps des Mines and those connected with the mining industry of France, and thus a void was filled up in the subjects taught which were not included in the course of study at the École Polytechnique. From 1845 to 1850 Delaunay was one of the most successful of the professors in this section, having classes for the teaching of descriptive geometry, stereotomy, machine drawing, analytical mechanics, and elementary physics. His manner of imparting knowledge was so clear, and so well appreciated by the pupils, that these classes became the most popular division of the school. In 1850 Delaunay attached himself exclusively to the École des Mines, and, like his predecessors, Lamé, Regnault, and Sénarmont, was appointed to successive grades in the Corps des Mines, becoming engineer-in-chief in 1858. In 1867 he was raised to the first class of his rank.

In 1841 M. Delaunay published his first memoir, entitled *Sur la Distinction des Maxima et des Minima dans les questions qui dépendent de la Méthode des Variations.* This was followed by other important works on various subjects, such as on the theory and precession of the equinoxes; theory of the tides; theory of the motion of the Moon; elementary treatises on astronomy and mechanics; and a large number of miscellaneous papers in the *Comptes Rendus*, in the additions to the *Connaissance des Temps*, and in the *Journal de l'École Polytechnique.* His first memoirs exhibited great mathematical power, and foreshadowed the scientific rank which he soon attained among geometers. Fortunately his attention was drawn to astronomical questions, in the discussion

of which he became so completely engaged that his whole leisure-time was devoted to this object. His treatise on the theory of the tides was an important work, and it was about this period that the question of the lunar theory first began to occupy his mind. His elementary books on astronomy and mechanics are excellent text-books for schools, in which he showed the rare talent how to popularise science without lowering it. In 1869 new editions of his *Cours élémentaire d'Astronomie*, and his *Cours élémentaire de Mécanique* were published, four of the former and six of the latter having been sold.

Delaunay's great work on the Lunar Theory is, however, that which has made his name so universally known among us, and for which the Royal Astronomical Society had the honour of electing him one of its Associates in 1862. Few of us, however, can properly estimate the magnitude of this voluntary labour of Delaunay. Most students of astronomy know to what extent an exact acquaintance with the motion of the Moon affects questions in astronomy and navigation; and they also know that there are very great mathematical difficulties presented in the process of determining the values of the co-efficients of the numerous lunar inequalities. If we were among the few able to express the motion of the Moon by analytical formulæ, in which no sensible term is neglected, from which tables could be formed free from empiricism, then we should be qualified to understand the immense work which mathematicians like Delaunay have undertaken to investigate. The necessity of carrying the approximation farther than had

been done in previous investigations of the Lunar Theory, increases the labour to an enormous extent.

It will be impossible and unnecessary in this very brief obituary notice to enter into the peculiarities of Delaunay's great work on the Lunar Theory. It was only in February 1870 that Professor Adams, F.R.S., presented to him, in the name of the President, the Gold Medal of the Royal Astronomical Society, as an acknowledgment of the high appreciation which is entertained for his work in this country. On that occasion, Professor Adams gave, with great minuteness, his testimony to the great value and importance of Delaunay's researches on the Lunar Theory, entering at the same time into a complete history of the subject, and pointing out in what Delaunay differed from those who had already published treatises on the theory. To this valuable address of Professor Adams, which is given *in extenso* in Vol. XXX. No. 4, of the *Monthly Notices*, any one who wishes to acquaint himself with the details of the process adopted by Delaunay in his research is referred.

From the year 1846 M. Delaunay devoted all his available time to the carrying out of this important work. After fourteen years of assiduous labour he published, in 1860, the first volume, entitled *La Théorie de la Lune*, forming one of the volumes of the Memoirs of the French Institute. During this interval he, in separate memoirs, published papers on several questions relating to the theory, notably that on the secular acceleration of the mean motion of the Moon, which at that time was a subject exciting much controversy. The magnitude even of this supple-

mentary work may be conceived from an extract from an interesting review of the state of this controversy in 1859, by the Rev. R. Main, F.R.S., then President of the Society.[1] 'The reader, who desires to see the exact expression for the acceleration arrived at by M. Delaunay, must consult the work referred to, as it is too long for insertion here, consisting, as it does, of *forty-two* terms. Thus much may be said of it, that it takes in every possible term as far as the eighth order, including those terms depending on the inclination and excentricity of the lunar orbit; and that all the terms calculated by Mr. Adams are in exact accordance with it.' In January 1867 the second volume of *La Théorie de la Lune* was presented to the Academy of Sciences, thus completing by far the most difficult portion of this vast undertaking. A third volume was intended by Delaunay to include several separate investigations in connection with the lunar theory, some of which had been previously published in the *Additions à la Connaissance des Temps* for the years 1862, 1863, 1864, 1865, and 1869. This concluding volume, however, has never appeared.

'This enormous labour, which has occupied M. Delaunay for nearly twenty years, has been performed by him without assistance from any one. Indeed, from the nature of the calculations which are required, it would not have been easy to obtain any effective assistance. In order to ensure accuracy, M. Delaunay has omitted no means of verification, and he has per-

[1] *Monthly Notices, R.A.S.*, vol. xix. p. 275.

formed all the calculations, without exception, at two separate times, with a sufficient interval between them to prevent any special risk of committing the same error twice in succession.

'The volumes before us are perfect models of orderly arrangement. Notwithstanding the great length and complication of the calculations, the whole work is so disposed that any part of it may be speedily examined with the utmost readiness by any one who may wish to test its accuracy.

'Finally, the analytical expressions which have been obtained for the Moon's co-ordinates are converted into numbers, by substituting for the elements the most accurate numerical values which the comparison of theory with observation has made known. . . . The work is complete in itself; in it the very difficult and complicated problem of determining the Moon's motion is attacked by a perfectly original method, and that one as powerful and beautiful as it is new. The work has been planned with admirable skill, and has been carried out with matchless perseverance. The result is an enduring scientific monument of which our age may well be proud, and which we are happy to distinguish, on this occasion of this our fiftieth anniversary, with the highest marks of our approval which it is in our power to bestow.'[1]

M. Delaunay visited London, as the guest of the late Admiral Manners, specially to receive the gold medal in person from the hands of his friend, Pro-

[1] Address of Professor Adams, on presenting the Gold Medal of the Royal Astronomical Society to M. Delaunay. *Monthly Notices, R.A.S.*, vol. xxx. pp. 131, 132.

fessor Adams, at the anniversary meeting of the Royal Astronomical Society held on February 11, 1870. He also took this opportunity to be formally admitted into the Royal Society as one of its Foreign Members, a ceremony which took place on the preceding evening.

No one knew better than Delaunay that his two noble volumes of theory, perfect as they may be in themselves in a mathematical point of view, would still leave the subject practically incomplete, unless the analytical expressions in them were reduced to the form of tables, so that the position of the Moon at any given time might be easily calculated. The preparation of lunar tables representing his theory was therefore being proceeded with, under his direction, at the time of his death. The Bureau des Longitudes took great interest in this portion of the work, and 60,000 francs were granted by the Government, on the advice of the Minister for Public Instruction, to defray the expense of the calculation and printing of the tables. Ten sheets had already been printed when their accomplished author was so suddenly taken away, and this at a time when more than his usual energy was thrown upon the work to hasten on its publication. The numerical calculations had been completed for a considerable portion of the tables, those for the longitude being in the printer's hands, and the remaining portion far advanced. After Delaunay's death the continuation of the work was entrusted by the Bureau des Longitudes to one of its members, with the hope that the calculations might be found in such a state as to allow

another skilled mathematician to complete the tables, and thus preserve to astronomy the fruit of so long and laborious an undertaking. But all this is now very doubtful. The master-mind, who alone was acquainted with all the details and singularities of his investigations, is no more, and it is believed that difficulties have arisen which may possibly be too great to overcome. But if the calculations are not so far advanced as was expected, still may we not have some hope that they may eventually be carried out to the end, and thus save our science from an irreparable loss? At any rate, every one must sincerely trust that the opinion of M. Puiseux, member of the Bureau des Longitudes, written a few days after the death of M. Delaunay, will be literally fulfilled:—'Quoique l'auteur ne soit plus là pour y mettre la dernière main, il ne sera sans doute pas impossible de terminer ce monument scientifique. Espérons pour la gloire de l'astronomie française, que ce service sera rendu à la science, que ce suprême hommage ne manquera pas à notre illustre confrère.'[1]

In March 1870, M. Delaunay was appointed Director of the Observatory of Paris, in succession to M. Le Verrier. Installed in his new office, Delaunay was soon convinced of the importance of the numerous improvements made in the condition of the Observatory since the death of Arago; and many times he has been heard to express his adhesion to several of the innovations introduced by his predecessor. He had not, however, long been resident at the Observa-

[1] It is feared by many that there is at present but little prospect of the completion of this noble work. (1879.)

tory when the terrible war broke out between France and Germany, which was intensified by the disasters consequent on the prolonged siege of Paris. His whole time and thoughts were now concentrated on the best means to be adopted for the preservation of the instruments from the effects of the bombardment. In this he fortunately succeeded; and not only was the Observatory preserved during the siege, but also from the destructive followers of the Commune of Paris. The following extract from a letter from M. Delaunay to his mother, dated April 23, 1871, enables us to form some idea of the confusion in the *personnel* of the Observatory during the reign of the Commune:—

'The Observatory has been spared to the present time, and I trust that it will be to the end. All the astronomers are gone, as well as the men-servants, the gardener, and the porter, so that they may avoid taking part in this fratricidal struggle. I am almost the sole inhabitant in the establishment, which has not yet been invaded, and probably it will not be. I have just been raising the red flag instead of the tricolour, according to an order which has been given to me by the Commune of Paris. I have with me an American astronomer[1] and his wife. He is working all day in our library, extracting from our ancient manuscripts the records which may prove useful in his researches. For my own part, I am also engaged in scientific work, almost as if peace prevailed throughout France; though the firing of cannon and rifles is almost constantly heard. I preside each week at the

[1] Professor Simon Newcomb, U.S.N.

meeting at the Academy of Sciences, which is attended by a very small number of members.'

At this time, all the delicate instruments in the Observatory were dismantled and stowed away in sheltered places, and all observations were in consequence suspended. Even this foresight and care nearly failed; for, during the last days of the Commune, their troops took possession of the building and grounds, which they turned into a military station. Although a few small instruments were destroyed, no very serious damage was done; but in the last moments of their power the soldiers threatened to set fire to the Observatory, making preparations to do so, when the rapid approach of the Versailles troops happily saved the building and its valuable contents from destruction. After the conclusion of peace the Observatory was soon restored to its former condition, and the usual observations were resumed.[1]

[1] The following interesting Notes, in the form of a diary, were written by M. Delaunay during the last days of the Commune. They show what a narrow escape the Observatory had from destruction. These Notes were found in the pocket-book carried by M. Delaunay at the time of the catastrophe at Cherbourg :—

'*Dimanche*, 21 *Mai* 1871.—Le soir, les becs de gaz du Trocadéro ne sont pas allumés. A minuit et demi, on vient me demander des *longues-vues marines* pour les batteries de Montmartre. Je déclare que je n'en ai pas.

'*Lundi*, 22 *Mai*.—Le matin, les troupes Versaillaises se voient clairement au Trocadéro. Je retire le drapeau rouge. Dans la journée on se met à faire des barricades près de l'Observatoire. Un capitaine avec une troupe d'hommes armés et un délégué francmaçon viennent de nouveau me demander des lunettes; je les conduis dans tout l'Observatoire pour leur montrer les grands instruments d'observation, et je leur déclare que je n'ai pas d'autres lunettes que celles qu'ils viennent de voir. Ils se retirent, et en passant devant le vestibule, ils

France can claim among its past and present mathematicians some of the greatest of astronomers, both theoretical and practical; but there has been a comparative absence in that country of the established public and private observatories so plentiful in England and Germany, and even in Italy. M. Le Verrier was deeply sensible of this deficiency of means for the practical advancement of astronomy, and Delaunay shared in this opinion. Being thus convinced of the importance of increasing the number of observatories, they made an application jointly to the Government for the pecuniary assistance required to establish a certain number of public astronomical and geodetical stations in widely separated parts of the country. This application was favourably received by the Government,

démolissent à grande peine une partie de la trappe qui ferme le puits des caves. Personne ne se couche. Je passe la nuit sur un canapé, dans le cabinet des élèves.

'*Mardi*, 23 *Mai.*—L'attaque de l'Observatoire par les troupes commence vers midi. Les insurgés tirent du haut de l'Observatoire. On tire avec acharnement de la barricade de la rue d'Enfer. Le soir, vers onze heures, incendie du couvent du Bon-Pasteur. Vers minuit, les insurgés, obligés de se retirer, mettent le feu dans l'antichambre du cabinet de Villarceau. On s'en aperçoit et on parvient à éteindre le feu. Les insurgés reviennent furieux et menaçants.

'*Mercredi*, 24 *Mai.*—L'attaque de l'Observatoire par les troupes continue. Les insurgés nous préviennent qu'ils vont mettre le feu partout, et que nous n'avons qu'à nous retirer avec ce que nous pourrons emporter. Nous nous réfugions tous dans le sous-sol situé au-dessous de la salle Méridienne. Vers onze heures et demie du matin, explosion de la poudrière du Luxembourg. Vers midi et demi, l'Observatoire est évacué par les insurgés et les troupes y entrent.

'*Jeudi*, 25 *Mai.*—Toute la journée on tire du jardin de l'Observatoire, d'abord des mitrailleuses et ensuite des canons.

'*Vendredi*, 26 *Mai.*—L'Observatoire étant entièrement délivré, je quitte Paris pour aller voir ma mère.'—*Thévenot's 'Delaunay.'*

with the understanding that the choice of stations and the organisation of the observatories should be arranged by Delaunay and the Bureau des Longitudes. The scheme was, however, only partially carried out; but the Observatory of Marseilles, which till then was only a branch of the Paris Observatory, was made an independent establishment, under the direction of M. Stéphan; the Observatory of Toulouse was founded, and placed under M. Tisserand; and it was proposed to found another observatory at Besançon.

In accepting the directorate of the Observatory of Paris, Delaunay was fully impressed with the deep responsibility attached to his office. In the first place, the internal discipline of the establishment required reorganisation; but, above all, he knew that he was the successor of one of the greatest mathematical astronomers of the age, and that for the honour of the Observatory it would be necessary to tread in his scientific footsteps, or its reputation would suffer. He perceived, in common with his predecessor, that the rapid progress of astronomy required corresponding efforts on the part of a great national Observatory like that at Paris to meet the demands continually being made for observations in different branches of the sciences of astronomy and meteorology. It is believed that, had his life been spared, he would not have been found wanting; for those who knew him best never doubted that he would make a successful director, and would succeed in his object of making the Observatory the great centre of astronomy in France. Shortly before his death he remarked: 'We are going to do many things; the

Observatory intends to devote all its energies to the re-observation of Lalande's Catalogue; to continue the ecliptic star-charts commenced by Chacornac; to observations of double stars; and, finally, we are making preparations for new determinations of the longitude of Brest, Greenwich, and Neuchâtel.' The observation of the minor planets during the second half of the lunation, according to the original convention agreed upon by the Astronomer Royal and M. Le Verrier in 1863, was continued by M. Delaunay with great success, excepting only during the investment of Paris by the German army.

When, in 1854, the administration of the Observatory of Paris was separated from that of the Bureau des Longitudes, M. Mathieu and M. Laugier, who had long been the associates of Arago, retired to a common residence in the Rue Nôtre Dame des Champs, where they established a small observatory. Delaunay, whose sympathies and habits were akin to those of Mathieu and Laugier, occupied an apartment in the same house. Hence arose that undivided friendship which lasted through life. It was here where he carried on most of his researches; he seldom went out, except to give his accustomed lessons at the École des Mines or the Sorbonne. It is said that he was in the habit of rising at five o'clock in the morning in summer and six in winter, and immediately commenced working. At eight o'clock he partook of a cup of *café au lait*, which was his only refreshment till one P.M., when he had his *déjeuner*. His morning was prolonged as long as possible, as he was unable to work at his lunar theory in the after-

noon, or after partaking of a heavy meal. His courses of lectures at the Sorbonne, in the military schools, or in some other establishment, were generally commenced at two; and the interval from four to six, whatever might be the state of the weather, he always devoted to a constitutional walk, either in the streets of Paris or on the exterior boulevards. It was while passing his life in this studious and regular manner, that the late Emperor Napoleon appointed him to the control of the Observatory. He accepted the directorate as a duty to his favourite science, but not without considerable sacrifice to his private comfort. He often appeared to regret leaving his late modest apartment and the daily association of his friends; and it was with sincere pleasure that he frequently, in thought, looked back on the happy hours consecrated to his researches, either within his Paris home or at his small country residence in Champagne.

At the age of twenty-three M. Delaunay was united in marriage to Marie-Olympe, daughter of M. Millot, chief registrar of the Civil Tribunal of Troyes. This lady, whose uncertain health was always an anxiety to her husband, died in 1849, leaving an only son, Gaston Delaunay, at present the principal guardian of the forests of Vitry le François. Delaunay's aged mother, to whom he was devotedly attached, survived him. As stated in the last paragraph in the document found on his body at Cherbourg, as soon as the safety of the Observatory was secured, his first thoughts reverted to his widowed mother, of whom he had heard no tidings after Paris was invested by the German army in September 1870, when the

intercourse with the outer world was suspended. The moment when it was possible for him to leave Paris after the final collapse of the Commune in May 1871, he hastened to Ramerupt, and in person related to his mother and friends all the cares and anxieties which had troubled him during the preceding eight months. In a few days he returned to his labours of reorganisation, in which he had been so cruelly interrupted by the late political events. Delaunay considered this episode in the history of the Observatory of sufficient importance to form the subject of a communication to the Academy of Sciences, read on June 5, 1871, giving an interesting account of the havoc made at the Observatory during the insurgent occupation on May 22, 23, and 24.

Delaunay was a member of several of the learned Societies; he also had received the honorary degree of Doctor in Science. He was a member of the Academy of Sciences of Paris, the presidential chair of which he had only lately filled. He was, as we have already remarked, a foreign member of the Royal Society and an Associate of the Royal Astronomical Society.

The circumstances of Delaunay's death were of the most melancholy character. In his full mental power, but needing some temporary recreation, he left the meeting of the Bureau des Longitudes on Tuesday, July 30, 1872, for the purpose of spending a few days on the coast of Normandy, in company with his cousin, M. Millot, Controller of the Post. On Sunday, August 4, he wrote from Bayeux that his health was excellent, that he intended passing

one or two days at Cherbourg, and return to Paris on Thursday following. On Tuesday morning a telegram was received in Paris in these words :—' Hier, à Cherbourg, un canot monté par quatre personnes a chaviré dans la rade. Les quatre personnes ont péri; l'une d'elles est M. Delaunay, Directeur de l'Observatoire de Paris. Son corps a été retrouvé à l'île Pelée, à cinq kilomètres de Cherbourg.' At eight o'clock in the evening on Monday his body was found on the shore, between some rocks, by the keeper of the semaphores. It was conveyed to Cherbourg, when it was at once identified as that of M. Delaunay by Admiral Penhoat, a member of the late Observatory Commission, and others. Thus, with his cousin and two boatmen, this distinguished and lamented astronomer suddenly met his death at the age of fifty-six, amid the regrets of the whole scientific world, and in the full powers of that gifted intellect which had been so long devoted to the successful development of some of the most important branches of mathematical astronomy.

The funeral service at the obsequies of M. Delaunay was celebrated on Friday, August 9, at the church of Saint Jacques-du-Haut-Pas, the pall-bearers being M. Liouville, representing the Academy of Sciences; M. Puiseux, representing the Bureau des Longitudes; M. Yvon Villarceau, representing the Paris Observatory; M. Daubrée, representing the Corps des Mines; M. Milne-Edwards, representing the Sorbonne; and General Riffaut, representing the École Polytechnique. There were also present deputations from the Institute, the Sorbonne, the École Polytechnique,

and the head Normal School, consisting of several of the foremost men of science. At the conclusion of the religious service the body was conveyed to Rame-rupt, where it was interred on the following day in the presence of nearly all the population of the place.

It is a singular fact that the family of M. Delaunay have, on former occasions, been called to mourn the loss of relations by drowning. Delaunay himself had a natural dread of the sea, and indeed of ships and boats of all kinds. Having this great aversion for boating, he must have been enjoying a great buoyancy of health and spirits at Cherbourg to have accompanied M. Millot on this fatal excursion. His friends cannot understand how he could have been prevailed upon to form one of the party, as the loss of his father and brother was ever present in his mind on an occasion of this kind. On August 5, 1846, exactly twenty-six years before, his father perished in the presence of his wife and son while bathing in an open river near Troyes; while his brother shared a similar fate some years afterwards, also while bathing, very nearly at the same spot as his father. These coincidences are very remarkable.

LIEUT.-GENERAL SIR W. T. DENISON, K.C.B., F.R.S.

1804–1871.

LIEUT.-GENERAL SIR WILLIAM THOMAS DENISON, K.C.B., R.E., was born in 1804. He was the son of John Denison, Esq., M.P., of Ossington, and brother of the late Right Hon. John Evelyn, Viscount Ossington, formerly Speaker of the House of Commons, and of the late Dr. Denison, Lord Bishop of Salisbury. After completing his preliminary studies he entered the Corps of Royal Engineers, in which he was distinguished as one of the most successful of the scientific officers employed under the direction of Colonel Colby, F.R.S., Superintendent of the Trigonometrical Survey of Great Britain. While serving with his corps he was frequently employed by Government on special engineering duties in England and the Colonies. On Lieutenant Denison's return from Canada, where he was engaged on the construction of the Rideau Canal, he was placed in charge of the course of topographical instruction for engineer officers and sappers at Chatham, in connection with which he established an astronomical observatory. He subsequently had control of the works at Woolwich and Portsmouth Dockyards, employing his leisure-time in editing the first series of Corps Papers on subjects

connected with civil engineering. He became a Fellow of the Royal Astronomical Society in 1834, and of the Royal Society in 1838.

The administrative ability of Captain Denison having been brought under the notice of the Secretary of State for the Colonies, he was appointed, in 1846, to the office of Lieut.-Governor of Tasmania. About the same time he received the honour of knighthood. In 1854 he was removed to Sydney, as Governor of New South Wales; and finally he was translated, in 1860, to the Governorship of the Madras Presidency. During his residence at Madras he was called upon to serve as acting Governor-General of India, in the few months' interval after the death of the Earl of Elgin in 1863, and the arrival of his successor Sir John Laird Mair (now Lord) Lawrence. Sir William Denison's brief administration of this high and responsible office gave complete satisfaction to the Home Government. He resigned his appointment as Governor of Madras in 1866, and returned to England in May of that year, thus closing a successful career as a Colonial Governor for the long period of twenty years.

While at Sydney and Madras Sir William Denison took a great interest in the promotion of astronomical observations in connection with the established observatories at these places, and he was ever ready to support anything which he considered advantageous towards the progress of astronomy. During his long absence from England he never failed to carry on a frequent correspondence on astronomical and other

questions with some of the principal scientific men of this country, by whom he was much esteemed.

Sir William Denison married, in 1838, Caroline Lucy, daughter of Admiral Sir Phipps Hornby. He was made a Knight Companion of the Bath in 1856, a Major-General in March, 1868, and a Lieutenant-General in the latter part of 1870. After his return to England he employed most of his leisure-time in the preparation of his most characteristic work, *Twenty Years of Viceregal Life;* and after a few years of arduous application to the duties of a River Commissioner, as well as a constant devotion to the interests of colonisation, he was called hence, after a very brief illness, on January 19, 1871, in the sixty-seventh year of his age, beloved by his private friends, and esteemed by those who were acquainted with the unblemished career of his public life.

PROFESSOR G. B. DONATI.

1826–1873.

PROFESSOR GIOVAN BATTISTA DONATI was born at Pisa, on December 16, 1826, and was the son of Dr. P. Donati, of that city. After his preliminary studies at the University of Pisa, where he had for his tutor M. Mossotti, an Associate of the Royal Astronomical Society, he devoted himself to the special study of mathematics, and to original analytical researches. On August 1, 1852, he was appointed to the Observatory of the Museum of Natural History at Florence, which at that time was under the direction of Professor Amici. In October 1854 he was made an *aide-astronome*; and on September 29, 1858, the title of *Astronome-adjoint* was conferred upon him, in consideration of his discovery of the magnificent comet which still bears his name.

At this time Donati had already attracted the attention of astronomers out of his own country by his cometary observations, the results of which had been inserted in various scientific publications, including the *Monthly Notices*, where his name first appears as an observer and discoverer of comets in 1855. His fortunate discovery of a small telescopic comet on June 2, 1858, which ultimately became the remarkable comet of that year, brought him at once

into general notice. From being a comparatively unknown observer, Donati found himself thus suddenly made the astronomical hero of the day; for his brilliant comet not only formed an interesting subject for intelligent study, on account of the various speculations as to its physical constitution, but it also created for a time a lively interest in astronomy among all classes of the community. Fortunately, Donati's zeal as an observer did not allow him to remain satisfied with the honour he had so unexpectedly attained, for we find him continuing with increased energy as an assiduous observer of comets and other astronomical phenomena. On December 22, 1859, he was appointed Professor of Astronomy and Director of the Observatory in which he had so faithfully served as an assistant during the preceding seven years.

On taking charge of the Observatory, Professor Donati's first thoughts were soon directed to the advisability of constructing a new Observatory at Florence, because the situation of the old building, owing to the glare of the street-lamps and the continual vibration produced by passing vehicles, was not adapted for delicate observations of precision. Donati himself alluded to this defect in the position of his Observatory at a meeting on the subject of the Great European Triangulation, held at Berlin, in 1864. He was from that time most anxious that a new national Observatory for Italy should be erected, to take rank with the principal observatories of other countries, and his aim was to have the direction of an establishment which could be adapted to the requirements of modern astronomy and general physics. To attain this object

he laboured hard for many years; and it was a great day for science at Florence when, on October 27, 1872, the new Observatory at Arcetri was solemnly inaugurated with great ceremony, although, from the effects of an accident, Donati unfortunately was unable to be present.

The original researches of Professor Donati, which have eminently contributed to enrich astronomical knowledge with many new ideas and discoveries, embrace the four following subjects: Comets, Stellar Spectra, Scintillation of Stars, and the Aurora Borealis. The observation of comets was, however, that which above all others was most attractive to him. From the commencement of his astronomical career to the end of the year 1864 he was the discoverer of six comets, on the following dates: June 4, 1854; June 3, 1855; November 10, 1857; June 2, 1858; July 23, 1864; and September 9, 1864.

Professor Donati paid considerable attention to spectroscopic observations; and his labours in this branch of astronomy are well known by his important work, contributed in 1860 to the Museum of Florence, *Intorno alle Strie degli Spettri Stellari*, and continued in vol. xv. of the *Nuovo Cimento*, 1862, and in the *Annali del Reale Museo di Fisica e Storia Naturale di Firenze*, 1865, new series, vol. i.

The experience gained by Professor Donati from his observations of the spectra of the stars induced him to study the phenomena observed in their scintillation; and his more than usual clearness of conception enabled him to give an explanation of the causes which produce scintillation, which he considered to be

a true solution of the question, and in conformity with the views of Alhazen, who attributed the phenomenon principally to the variations in the atmospheric refraction.

Already Professor Donati, in the first year of the existence of his new Observatory, had commenced a series of Notes, commencing with an account of some observations of the luminous phenomena of the great aurora of February 4 and 5, 1872. He deduced from the observations a general corollary that the phenomena observed during this great aurora were a series of successive formations from the east to the west, proportional to the difference of the longitude between the various stations from which they were observed, and consequently that they had a movement strictly connected with the apparent motion of the Sun. Admitting this fact, Professor Donati was constrained to believe that the luminous appearances of this aurora could not have been derived from a purely terrestrial, meteorological, or electro-magnetical phenomenon, but that they had a cosmical origin. Hence he has considered that these phenomena really belong to the domain of a new science, to which he has given the name of 'Cosmical Meteorology.'

In 1860 Professor Donati published two papers under the title of *Memorie Astronomiche*—one on the striæ of stellar spectra, mentioned above; and the second giving an account of his observations of the total eclipse of the Sun, made at Torreblanca, in Spain, in the year 1860. He was elected an Associate of the Royal Astronomical Society on November 11, 1864.

In the autumn of 1873 Professor Donati attended, as the representative of his Government, the International Meteorological Congress held at Vienna. This meeting of scientific men, interested in meteorological observations, had successfully terminated, and Donati was on his return journey to Florence, when he was suddenly attacked with virulent Asiatic cholera. He was compelled to remain at Padua during the worst paroxysms of the disease, and it seemed extremely doubtful whether his strength would be sufficient to enable him to bear the fatigue of the remaining part of the railway journey. The crisis, however, appeared to have passed away, and with some difficulty he reached Florence. Within a few hours after his return, a relapse took place, which ended in death, on the early morning (0.30 A.M.) of September 20, 1873, at his residence, near the new Observatory at Arcetri, which he had laboured so long to establish, and which, it is hoped in the hands of his successors, will continue to be his appropriate memorial for many generations. He was in the forty-seventh year of his age.[1]

[1] It is to be regretted that the scientific success of the Arcetri Observatory has been much impeded for want of the necessary funds required for carrying out the intentions of Professor Donati.

PROFESSOR EDUARD HEIS.

1806–1877.

EDUARD HEIS was a native of Cologne, where he was born on February 18, 1806. He completed his education at the University of Bonn in 1827, in which year he became a teacher of mathematics and physics in the Friedrich-Wilhelm Gymnasium at Cologne, where he resided during the succeeding ten years. In the year 1837, his talents as a teacher having become known to the authorities of the High School at Aix-la-Chapelle, he was induced by them to accept the principal mastership for mathematics, physics, and chemistry in that school. He remained in this position till 1852, to the advantage of his pupils, among whom he was extremely popular. It was while he was employed at this establishment that his acuteness of vision led him to undertake that long series of records of the relative brightness of the stars, as viewed with the unassisted eye, which have formed the materials for that excellent and standard atlas and catalogue of stellar magnitudes, published under the title of *Atlas Cœlestis Novus*. During this period he also found ample opportunities for observing various other celestial phenomena, especially of the zodiacal light, of occasional meteors, bolides, and the periodic recurrences of meteor showers.

In 1852 Dr. Heis was transferred to Münster, in Westphalia, having received the appointment of Professor of Mathematics and Astronomy in the Royal Academy of that city. This office, in conjunction with that of Director of the Observatory, he retained to the end of his life.

Dr. Heis became known as a scientific writer soon after he completed his studies at the Bonn University. He employed his leisure hours in the intervals of his ordinary scholastic duties at the Cologne Gymnasium chiefly in the study of botany, and his first published paper in 1828 was devoted to a botanical investigation *Ueber die Structur der Pflanzenzellen.* Other papers relating to the same branch of science followed, and for some time afterwards botany was evidently his chief recreative pursuit. He may possibly have taken an occasional interest in the appearance of irregular celestial phenomena, but we can find no record before 1833 bearing even slightly on his future astronomical eye-observations; and it is tolerably certain that at this time his thoughts were little occupied on astronomy as a subject of research. In 1833 he commenced his Notes on the appearance and direction of motion of shooting stars. It may be interesting to remark that his first recorded observation of a meteor was made on October 2 of that year, at seven in the evening, when he noticed, from Steinheim, near Hanau, a fireball appear near *α Andromedæ*, passing through *Cygnus* to near *Vega*, where it exploded. His second recorded observation was not made till August 10, 1839, between which date and November 1847 occa-

sional meteors only were observed by him, a few in almost every year. In 1847 Dr. Heis published his first paper on the meteors observed to that date, and this has been followed by several others at frequent intervals in connection with meteoric astronomy. Before his sudden death Dr. Heis had collected all his meteor-observations from 1833 to 1875, and arranged them in a convenient form for publication in one volume, forming vol. ii. of the *Publications of the Royal Observatory at Münster*, and the revision of the greater number of the proof-sheets was made by him before they were passed for press. This valuable work, *Resultate der in den 43 Jahren 1833–1875 angestellten Sternschnuppen Beobachtungen*, contains the right ascension and declination of the points in the heavens of the beginning and ending of the track of each observed meteor, which on some days amounted to several hundreds. No one more than he took greater pleasure in recording any special observations of meteors, especially of the periodical showers belonging to the principal August and November streams, the full details of which are contained in this volume. Dr. Heis was also an assiduous observer of the aurora borealis and the zodiacal light, and he never willingly lost an opportunity of increasing the number of observed facts relating to these phenomena at successive appearances. The results of his observations and investigations on these subjects have been published from time to time in various scientific serials; but those on the zodiacal light have been collected and discussed by Dr. Heis

in the first volume of his Observatory publications, which appeared in the year 1875.

Professor Heis had at various times paid particular attention to the variability in the magnitude of the larger periodic stars; among these *Algol*, *Mira Ceti*, and χ *Cygni* were favourite objects of observation. Their periodical variations of magnitude were carefully noted by him, and his deduced periods of variability of these stars are considered to be most trustworthy. He was indebted to his friend Professor Argelander, whose experience in the observation of stellar magnitudes was perhaps greater than that of any other astronomer, for some valuable suggestions as to the best method of making the comparisons of magnitude on different days, and which he advantageously adopted in his observations.

But the work which will connect the name of Professor Heis with the history of astronomy of the present century is undoubtedly his *Atlas Cœlestis Novus*, consisting of twelve maps, accompanied by an index-catalogue arranged according to the constellations, the result of a twenty-seven years' continuous examination of the relative magnitudes of nearly all the stars visible to the naked eye from the latitude of Münster. In preparing this work for the press, Dr. Heis had the advantage of having Argelander's *Uranometria Nova* before him, the same form and arrangement of the tables in the index-catalogues being evident in both works. In some cases Heis has been apparently influenced by the published magnitudes of Argelander; but, though

there is a considerable agreement in the corresponding values, we believe that, taken as a whole, Heis's magnitudes may be depended upon as independent estimations. In the *Atlas Cœlestis Novus*, he remarks that they were derived from a method devised by himself, and that he used every means to avoid any possible influence from the magnitudes published by Argelander or other observers. In the *Atlas* the varying luminosity of the Milky Way is represented in different shades with a good effect; but the insertion of the figures of the constellations in addition to the boundaries is rather distracting to the eye, and for this reason it would have been better had they been omitted. Dr. Heis's unusually acute vision enabled him to see smaller stars with the unassisted eye than most ordinary observers; and it is rather remarkable that he should have been able to note the magnitudes of 2,153 stars which had been passed over by Argelander, of which 1,821 are smaller and—what is more remarkable—thirty-four greater than the sixth magnitude. The whole number of stars contained in the catalogue whose magnitudes are recorded is 5,421. The great excess of stars in the *Atlas Cœlestis Novus* over those in the *Uranometria Nova*, especially of the six-and-a-half magnitude, gives to the former a value peculiar to itself. It appeared in 1872 as an atlas in folio, with the index-catalogue in octavo. Its publication brought Dr. Heis's name prominently before astronomers out of Germany; attention was thus more directed to this hard-working professor, whose continuous labours had hitherto only been appreciated by those who took a common interest

with him in the observation of meteors, the aurora borealis, the zodiacal light, and other occasional astronomical phenomena. On January 9, 1874, his important and original work was recognised in England by the Royal Astronomical Society electing him a Foreign Associate.

Professor Heis was the editor of a German astronomical periodical, entitled *Wochenschrift für Astronomie*, which, though well known in Germany, had only a limited circulation out of that country. Several of his contributions to meteoric astronomy and other subjects have appeared in that journal, which accounts for so few of them having come under the eyes of English astronomers. Some of his most valuable papers may, however, be found in the *Astronomische Nachrichten*, the *Bulletins de l'Académie Royale de Bruxelles*, and a few other serial publications generally available for reference in public libraries. His sole contribution to the *Monthly Notices* is a list of radiant points of meteors observed within the eleven years preceding 1860. He is also the author of a popular collection of examples and problems in general arithmetic and algebra, which has passed through a considerable number of editions in Germany.

Professor Heis remained an active worker in meteoric astronomy to the last, and it has been already remarked that at the time of his death he was engaged in passing his extensive collection of meteor observations through the press. He died suddenly of apoplexy on June 30, 1877, in the seventy-second year of his age. His name will remain honoured

among scientific men as representing a zealous, hard-working, and careful observer, who, regardless of personal inconvenience, has accumulated a vast store of results of great practical utility to his fellow-observers, as well as to the science of astronomy generally.

SIR JOHN F. W. HERSCHEL, Bart., K.H., F.R.S.

1792-1871.

AMONG modern English men of science no one has been more known, or has attained a higher rank as a writer on astronomy and general physics, than Sir John Herschel. His father had, however, laid the foundation of his honoured name in science, now a household word wherever astronomy is cultivated. The *Philosophical Transactions* of the Royal Society, beginning with the year 1780, and the *Memoirs* and *Proceedings* of other Societies have, since that time, been frequently enriched with papers and observations bearing that illustrious name. Rarely do we see such family talent exhibited in scientific researches as that possessed by the two Herschels; and it is remarkable that this hereditary talent is not exhausted in the third generation. The circumstances of the early lives of these two great astronomers and philosophers could not have been more widely different. Sir William, born in comparative obscurity, and without a trained education, was unknown in scientific circles till he was entering upon middle life. By his great natural genius and power of application, he, however, in a few years, soon attained the proud position of the most celebrated astronomer of the age,

and the successful constructor of a gigantic forty-feet reflecting telescope, which for a long time had no rival. Sir John, on the contrary, had as a youth the example of his father to guide him in his scientific tastes, which, added to the highest university training capable of being received at Cambridge, enabled him in early manhood to develop those great mathematical powers which he was known to possess, and which, in his more mature years, so materially assisted him in his investigations. This combination of high education and an extraordinary talent for communicating his thoughts to the world in an elegant and attractive manner, was the means of making Sir John so distinguished as a popular writer through the whole course of his life.

JOHN FREDERICK WILLIAM HERSCHEL was born at Slough, near Windsor, on March 7, 1792. He was the only child of Dr. Herschel (afterwards Sir William), whose career as an astronomer was then fully established. William Herschel was a native of Hanover, and, being an excellent musician, he joined the band of the Hanoverian regiment of Guards, which was ordered to England towards the end of 1755. After undergoing several privations, he obtained an engagement as organist at Halifax, which he afterwards exchanged for a more lucrative appointment at Bath. It was in this city that he first began his astronomical observations, and his first papers communicated to the Royal Society were written in the leisure intervals of his professional duties. After his discovery of *Uranus*, he was sought after by the highest ranks of society, including the King and Royal

Family, who were frequent visitors to his observatory at Slough. Here he remained actively employed till within a few years of his death, which took place in 1822.

The future career of John Herschel could not fail to be influenced in some measure by the philosophic ideas of his father; and a pleasing illustration of the way in which his inquiring and youthful mind was guided is given in the interesting *éloge*[1] in the Annual Report of the Council of the Royal Astronomical Society for February 1872, of which the following is an extract: 'A few traits of his boyhood, mentioned by himself in his maturer life, have been treasured up by those who were dear to him; and the record of some of them may satisfy a curiosity as pardonable as inevitable, which craves to learn through what early steps great men or great nations become illustrious. His home was singular, and singularly calculated to nurture into greatness any child born as John Herschel was—with natural gifts capable of wide development. At the head of the house there was the aged, observant, reticent philosopher; and rarely far away was his devoted sister, Caroline Herschel, whose labours and whose fame are still cognisable as a beneficent satellite to the brighter light of her illustrious brother. It was in the companionship of these remarkable persons, and under the shadow of his father's wonderful telescope, that John Herschel passed his boyish years. He saw them, in silent but ceaseless industry, busied about things

[1] By the Rev. Charles Pritchard, M.A., F.R.S., Savilian Professor of Astronomy in the University of Oxford.

which had no apparent concern with the world outside the walls of that well-known house, but which, at a later period of his life, he, with an unrivalled eloquence, taught his countrymen to appreciate as foremost among those living influences which best satisfy and elevate the noblest instincts of our nature. What sort of intercourse passed between the father and the boy may be gathered from an incident or two which he narrated as having impressed themselves permanently on the memory of his youth. He once asked his father what he thought was the oldest of all things. The father replied, after the Socratic method, by putting another question: "And what do you yourself suppose is the oldest of all things?" The boy was not successful in his answers, whereon the old astronomer took up a small stone from the garden walk: "There, my child, there is the oldest of all the things that I certainly know." On another occasion his father is said to have asked the boy, "What sort of things, do you think, are most alike?" The delicate, blue-eyed boy, after a short pause, replied, "The leaves of the same tree are most like each other." "Gather, then, a handful of leaves from that tree," rejoined the philosopher, "and choose two that are alike." The boy failed; but he hid the lesson in his heart, and his thoughts were revealed after many days. These incidents may be trifles; nor should we record them here, had not John Herschel himself, though singularly reticent about his personal emotions, recorded them as having made a strong impression on his mind. Beyond all doubt, we can trace therein, first, that grasp and grouping of many things in one,

implied in the stone as the oldest of things; and, secondly, that fine and subtle discrimination of each thing out of many like things, as forming the main features which characterised the habit of our venerated friend's philosophy.'[1]

At the age of seventeen young Herschel entered St. John's College, Cambridge, from which he graduated B.A. in 1813 as Senior Wrangler, having for his competitors the late Dr. Peacock, Dean of Ely, who was Second Wrangler, and the late Rev. Fearon Fallows, His Majesty's Astronomer at the Royal Observatory, Cape Town, the Third Wrangler. The names of several other noted men appear in the honour-list as contemporary students, including Professors Amos (Law), Mill (Hebrew), and Scholefield (Greek), Dr. Robinson, Master of the Temple, and Bishop Carr, late of Bombay. Mr. Herschel had no sooner taken his degree than he forwarded a mathematical paper to the Royal Society, 'On a Remarkable Appearance of Cotes's Theorem.' This first communication was published in the *Philosophical Transactions*. In the same year he was elected a Fellow of the Royal Society, and, though so young, he soon became an active member of that first of English scientific Societies. The date of his election is May 27, 1813, he at the time having only just completed his twenty-first year.

Soon after Mr. Herschel quitted Cambridge, he placed himself under a practising barrister, with the object of being called to the Bar, as so many of the High Wranglers had previously done, some of whom

[1] *Monthly Notices, R.A.S.*, vol. xxxii. p. 123.

attained the highest positions on the Bench. He commenced keeping his terms in the Temple in February 1814. But he had not been long in London before he became acquainted with Dr. Wollaston, F.R.S., and Mr. (afterwards Sir James) South, F.R.S., in whose scientific work he soon took a great interest; and thus that dormant taste which he possessed for general physics, astronomy, and chemistry, gradually weaned him from those technical studies which he would have been called upon to undertake had he desired to assume a foremost place in the legal profession.

The early researches of Mr. Herschel were chiefly confined to pure mathematics. Most of these are published in the *Philosophical Transactions*; and they were considered of sufficient merit to gain for him the approbation of the members of the Council of the Royal Society, who in 1821 awarded him the Copley Medal. Before this he had turned his attention to astronomy, especially to what may be termed 'observing' astronomy in contradistinction to 'pure mathematical' astronomy. By the death of his father in 1822, and becoming the possessor of the great four-feet reflector, the practical branch of the science naturally descended to him as an hereditary duty, and thus he commenced that long series of stellar observations, which only ceased after he had surveyed the heavens in both hemispheres. About this time the Royal Astronomical Society was founded by a few well-known astronomers, who were mostly Fellows of the Royal Society. Herschel was one of the first to associate with his friends in forming the new Society,

which was intended to be devoted exclusively to the promotion of astronomical research. A few years previously to the death of Sir William Herschel, principally owing to the great improvement in the construction of telescopes, many amateur astronomers sprang up, who became well known as accurate observers and delineators of the heavenly bodies.[1] To Dr. Pearson, F.R.S., whose first thoughts on the subject go back so far as 1812, is due the honour of suggesting the formation of an Astronomical Society; but it was John Herschel who drew up the original address, which is always looked upon as the first publication of the present Royal Astronomical Society, now (1879) in the sixtieth year of its existence. The nominal foundation of this important Society dates from a private dinner, to which Dr. Pearson invited the principal astronomers resident in or near London. The exact date of this dinner is not known; but the meeting at which the Society was definitely constituted was held at the Freemasons' Tavern on January 12, 1820, and was summoned specially to take into consideration the propriety and expediency of establishing a Society for the encouragement and promotion of astronomy. Professor De Morgan, some years afterwards writing on this subject, remarked: 'It thus appears that Dr. Pearson kept the plan in his head, where it lived through his transformation from

[1] One of these, Mr. Stephen Groombridge, F.R.S., furnished a private observatory at his residence in Eliot Place, Blackheath, where he made a most valuable series of meridional observations of circumpolar stars. This observatory, though now incorporated in the dwelling-house, may still (1879) be identified, and is believed to be but little altered in form since it was the scene of Groombridge's labours.

a thriving London schoolmaster into a country rector and magistrate; that he got together a number of astronomers to join him, and lubricated the business, to use Sam Johnson's phrase, by a dinner. I may be permitted so much reference to our age and country as will appear in a slight alteration of Molière's text:

"Le véritable fondateur
Est le fondateur où l'on dine."[1]

The Astronomical Society was one of the first offshoots from the Royal Society, and it at once entered on its successful career. Mr. Herschel took an active share in the management of the infant Society; but this did not in the least diminish the interest which he had always felt in the Royal Society, for he was often a member of its Council, and from 1824 to 1827 he served as one of its secretaries.

The principal branch of astronomical observation followed by Mr. Herschel at this period was the measurement of the angular distances and positions of double or triple stars, and the positions of nebulæ and clusters of stars. These researches occupied many years of his observing life. His first observations of double stars were made in 1816; but from 1821 to 1823 he associated himself with Mr. South in a plan for the re-observation of the double stars discovered by his father. Mr. South, who at that time was in practice as a surgeon, had a private observatory at his residence in Blackman Street, Southwark, in which he was accustomed to observe with

[1] Letter from Professor De Morgan to the President on the foundation of the Society.

instruments, described by Mr. Baily, in 1826, as 'a princely collection of exquisite workmanship, and considerable magnitude, such as have never yet fallen to the lot of a private individual.'[1] It was here that Mr. Herschel made, with Mr. South, that valuable collection of double-star observations which forms a complete part of the *Philosophical Transactions*, and for which they jointly received medals from the Astronomical and Royal Societies, and also the Lalande Medal of the French Institute. Mr. Francis Baily, F.R.S., President of the Astronomical Society, on delivering the gold medal to Mr. Herschel on April 14, 1826, addressed him in the following words: 'In the name of the Astronomical Society of London,[2] I present to you this medal. You will accept it, sir, as a mark of the deep interest which this Society takes in the object of your labours. Be assured that we are pleased to see from the paper presented to us this evening[3] that the subject still occupies your attention, and that it is likely to be pursued with so much energy and zeal by one who can so fully appreciate the importance of such inquiries, and who is so competent to conduct investigations of this kind. We trust that you will have health and strength to pursue the path which you have thus commenced with so

[1] *Memoirs, R.A.S.*, vol. ii. p. 547.

[2] The Charter granting the title of 'Royal Astronomical Society' is dated March 7, 1831.

[3] 'Account of some Observations made with a Twenty-feet Reflecting Telescope: comprehending—1. Descriptions and approximate Places of 321 new Double and Triple Stars. 2. Observations of the Second Comet of 1825. 3. An Account of the actual State of the Great Nebula in *Orion*, compared with those of former Astronomers. 4. Observations of the Nebula in the Girdle of *Andromeda*.'

much honour to yourself and so much benefit to science. Inheriting, as you do, those rare and exalted talents which distinguished your venerable and honoured father, and aided by the resources of your own powerful and enlightened mind, you have already opened another and very interesting field of inquiry and research in this particular branch of astronomy, by proposing *a new method of applying such observations to the investigation of the parallax of the fixed stars;* a subject which cannot be fully appreciated till after the lapse of many years, and which we hope will not be lost sight of by those who are engaged in investigations of this kind. The name of Herschel, doubly connected as it thus is with the history of astronomy, can perish only with the records of science. The splendid example of the father has been emulated by the son; and you have the proud and enviable satisfaction of knowing that you will share the glory of his immortal name.'[1]

It was, however, at Slough where Mr. Herschel imposed upon himself the duty of re-examining the double stars and nebulæ observed by his father. Here he worked night after night for a number of years, till he had accumulated sufficient observations of double stars to form six separate communications to the Astronomical Society, the last of which appeared in vol. ix. of the *Memoirs*.[2] The instrument employed by him was a reflecting telescope, the

[1] *Memoirs, R.A.S.*, vol. ii. p. 546.

[2] A seventh and final catalogue of new double stars, consisting principally of omissions from his former catalogues, is printed in vol. xxxviii. of the *Memoirs of the R.A.S.*

aperture or clear polished surface of its mirror being about eighteen inches, and its focal length twenty feet. It was constructed in the year 1820, under the joint superintendence of father and son, on the model of that used by the former in his *Sweeps of the Heavens*, which it superseded on account of the woodwork of the old instrument being much decayed. The less perishable portions were utilised in the construction of the new instrument. The grinding and polishing of the speculum was performed by Mr. Herschel himself; and he remarks that 'though certainly capable of considerable improvement in point of figure, such as at a convenient opportunity I propose to give it, yet on the whole I have no reason to regret the time and trouble bestowed on it. Its light with its full aperture is such as to reach with facility the faintest nebulæ of the third class in my father's catalogues, and even to add to their number; while its distinctness, with an aperture limited to twelve inches, is sufficient for the definition of double stars of the first class of an average degree of closeness, and when turned on objects of a sensible diameter, as the Moon and planets, yields in distinctness to no telescope I have yet seen, showing with the reality of a tangible object, the most microscopic inequalities in the Moon's surface, the planetary disks of *Jupiter*'s satellites, and all the delicacies of *Saturn*'s ring, belts, &c., which are usually chosen as tests of the performance of telescopes.' [1]

The process of sweeping in the meridian employed by Sir William Herschel consisted in giving a con-

[1] *Memoirs, R.A.S.*, vol. ii. pp. 459–460.

stant and regular motion to the telescope in polar distance, to the extent of about two degrees, the proper movements being made by the aid of a labouring assistant, while the readings of polar distance and right ascension were generally recorded by Caroline Herschel, the constant companion and assistant of her brother. John Herschel was, however, compelled by circumstances to make considerable modifications in the method as followed by his father; and he writes that these 'modifications were rendered necessary by the loss of my aunt's personal assistance, on whom the task of reading and registering the polar distances and right ascensions of objects, writing down the remarks and descriptions, warning the observer of expected stars, and finally reducing and calculating the whole, used invariably to devolve. Unsupported by such aid, I am under the necessity of recording the observations myself; an inconvenience of the worst kind, not only as it diminishes by, at least, one-half the number of objects that can be taken, but because the frequent admission of extraneous light into the eye is fatal to the observations of the fainter nebulæ. However, by a disposition of the apparatus adapted to the change of circumstances, I have succeeded tolerably well in bringing the whole process within reach, without the necessity of a change of place, and even in getting rid of some sources of inaccuracy, which were unavoidable in the former system.'[1]

In 1827 Mr. Herschel was elected, for the first time, President of the Astronomical Society of London. On two subsequent occasions he also filled the chair

[1] *Memoirs, R.A.S.*, vol. ii. p. 461.

for the usual period of two years. His addresses on presenting the gold medals are acknowledged to be among our best specimens of astronomical literature; and several of them have been reprinted, with other essays, in a volume published in 1857. The labours of the following astronomers have thus been immortalised in elegant, but at the same time accurate, language: Mr. Baily, Colonel Beaufoy, M. Bessel (twice), Sir Thomas Brisbane, Mr. Dunlop, Mr. Lassell, Dr. Pearson, M. Plana, M. Schumacher, and Lieutenant Stratford. Several of the most important obituary notices of deceased Fellows read before the Society are also from his pen, the longest of which is that of his friend Mr. Francis Baily, in vol. xv. of the *Memoirs* and vol. vi. of the *Monthly Notices*.

In 1831 Mr. Herschel received the honour of knighthood from the hands of King William IV., in company with a few others eminent in science.

On November 30, 1833, Sir John Herschel was presented by the Royal Society with one of the Royal medals, for his paper *On the Investigation of the Orbits of Revolving Double Stars*. This paper, read before the Royal Astronomical Society, and printed in the fifth volume of the *Memoirs*, is a supplement to another paper in the same volume on the micrometrical measures of 364 double stars made with the seven-feet equatorial at Slough. The presentation of the medal was made by the President, the Duke of Sussex, from whose address we extract the following remarks, which, though highly complimentary, are faithful representations of the exalted work and character of the medallist. The Duke himself was no

stranger to the recent advances made in astronomy, and to the share which the two Herschels had contributed to this increased knowledge of the constitution of the universe. He, therefore, spoke as follows, and as one intimately acquainted with the subject: 'Sir John Herschel has devoted himself, as you well know, for many years at least, as much from filial piety as from inclination, to the examination of those remote regions of the universe into which his illustrious father first penetrated, and which he has transmitted to his son as an hereditary possession with which the name of Herschel must be associated for all ages. He has subjected the whole sphere of the heavens within his observation to a repeated and systematic scrutiny. He has determined the position and described the character of the most remarkable of the nebulæ. He has observed and registered many thousand distances and angles of position of double stars, and has shown, from the comparison of his own and other observations, that many of them form systems whose variations of position are subject to invariable laws. He has succeeded, by a happy combination of graphical construction with numerical calculations, in determining the relative elements of the orbits which some of them describe round each other, and in forming tables of their motions; and he has thus demonstrated that the laws of gravitation, which are exhibited, as it were, in miniature in our own planetary system, prevail also in the most distant regions of space: a memorable conclusion, justly entitled by the generality of its character to be considered as forming an epoch in the history of astro-

nomy, and presenting one of the most magnificent examples of the simplicity and universality of those fundamental laws of nature by which their Great Author has shown that He is the same to-day and for ever, here and everywhere. . . . '

'It has been said that distance of place confers the same privileges as distance of time, and I should gladly avail myself of the privilege which is thus afforded me by Sir John Herschel's separation[1] from his country and friends, to express my admiration of his character, in stronger terms than I should otherwise venture to use; for the language of panegyric, however sincerely it may flow from the heart, might be mistaken for that of flattery, if it could not thus claim somewhat of an historical character; but his great attainments in almost every department of human knowledge, his fine powers as a philosophical writer, his great services and his distinguished devotion to science, the high principles which have regulated his conduct in every relation of life, and, above all, his engaging modesty, which is the crown of all his other virtues, presenting such a model of an accomplished philosopher, as can rarely be found beyond the regions of fiction, demand abler pens than mine to describe them in adequate terms, however much inclined I might feel to undertake the task.'[2]

A second Royal medal was awarded to Sir John Herschel on November 30, 1836, for his *Catalogue of Nebulæ and Clusters of Stars*, published in the *Phi-*

[1] Sir John Herschel and family had left England for Cape Town a few weeks previously.

[2] *Proceedings of the Royal Society*, vol. iii. pp. 223, 224.

losophical Transactions for 1833; and a third on November 30, 1840, for his paper on the chemical action of the rays of the solar spectrum on the preparation of silver and other substances, both metallic and non-metallic, and on some photogenic processes. The Royal Astronomical Society also awarded their gold medal to him for his *Catalogue of Nebulæ*, &c.

It is only necessary to read Sir John Herschel's own remarks in the introduction to his catalogues to notice that he had a profound sense of reverence for the labours of his father, with whom he was frequently associated in joint astronomical investigations. It is, therefore, natural that the son should become interested in the branch of astronomy in which his father had excelled; hence, probably, the reason why so much of the observing time of Sir John was devoted to the observation of double stars and nebulæ. One of his first communications to the *Memoirs* of the Astronomical Society is, however, an account of the great nebulæ of *Andromeda* and *Orion*, accompanied by a beautiful engraving of the latter, and a comparison of the apparent changes which seem to have occurred in the interval since the former delineations of the nebulæ had been made. From the date of making these drawings to the middle of 1833, his whole energy was given to the observation of the positions and delineations of nebulæ, the fruits of which were incorporated in his great catalogue. This catalogue contains a list of 2,500 nebulæ and clusters, of which all the right ascensions and declinations were determined, and the general character of their appearance recorded; but what perhaps appears more

attractive to the general reader is, that nearly 100 of those which presented any very extraordinary character, shape, or constitution, are drawn with precision in great detail, with a delicacy of finish which has been universally admired. It is remarkable that the list of nebulæ in this catalogue contains the same number which had been observed and catalogued by Sir William Herschel, 2,000 of them being common to both, and the remaining 500 are entirely new. Mr. Airy (now Sir G. B. Airy, F.R.S.), Astronomer Royal, in his address to the Fellows at the anniversary meeting of the Royal Astronomical Society, held on February 12, 1836, says: 'In conclusion of the work, and forming one of the most important parts of it, are the engraved representations of the most remarkable nebulæ. Let it not be supposed that I am overrating the value of these drawings. The peculiarities which they represent cannot be described by words or by numerical expressions. It would be absurd to attempt to define the place of every point of a nebula, and the intensity of light there, by co-ordinates of any kind. These maps contain that which is conspicuous and distinctive to the eye, and that which will enable the eyes of future observers to examine whether secular variation is perceptible. By such representations only can the existence of annual parallax be discovered. They are, in fact, the most distinct and most certain records of the state of a nebula at any given time. Few observers possess the delicacy of hand of Sir John Herschel.'[1]

In later years, Sir John Herschel gave to the

[1] *Monthly Notices, R.A.S.*, vol. iii. pp. 173, 174.

world a greatly enlarged general catalogue of nebulæ and clusters of stars. This valuable work was read before the Royal Society on November 19, 1863. It contains all the nebulæ and clusters which have been anywhere described, and sufficiently identified in position to warrant their inclusion. The compilation of such a work was one of enormous labour; and it affords a good example of the energy and perseverance of the aged philosopher, who, at threescore years and ten, found time and inclination to arrange and edit so valuable a catalogue, involving so much personal labour.

Since the publication of Sir John Herschel's first catalogue of nebulæ, several other astronomers have been engaged on the observation and delineation of this class of objects, notably the Earl of Rosse, F.R.S.; M. D'Arrest, of Copenhagen; Padre Secchi, of Rome; Professors W. S. and G. P. Bond, of the Harvard College Observatory; Dr. Auwers, and others. To Dr. Auwers we owe a catalogue comprising the whole of Sir William Herschel's nebulæ, arranged in order of right ascension, and reduced to a common epoch. The advantage to the observer of such a working-list of nebulæ was duly appreciated; but it appeared to Sir John Herschel that astronomy would be far greater benefited, if all available observations were collected together and included with his own in one combined catalogue, thus bringing into one tabular arrangement all the nebulæ and clusters actually known, and observed in both hemispheres. We should then be in a position to refer to one list for all that may be required, instead of having to turn over

the leaves of many volumes, some of which may be difficult to obtain. The epoch chosen for the new catalogue is 1860; so that observers, for some years after its publication, would be able to direct their telescopes to any nebula, and to ascertain at once whether it was one which had been previously observed. Many nebulæ (from the want of such a general catalogue) which had been supposed to be new, have afterwards been identified with others already described and well known. Many supposed comets also have been subsequently recognised as nebulæ; and much time would have been saved to observers in searching for them again on future nights, if a general catalogue like that now prepared by Sir John Herschel had at the time been available.

There was, however, another consideration which influenced Sir John Herschel to devote so much of his time to the preparation of this valuable contribution to astronomy. In the course of his own observations he had derived the greatest possible assistance from a manuscript catalogue of nebulæ and clusters discovered by his father, all brought to the common epoch of 1800. The right ascensions and declinations had been reduced by Miss Caroline Herschel; and it was only a debt of gratitude on the part of Sir John Herschel, as he himself expresses it, to make some acknowledgment of this assistance, and to complete the list of his own nebulæ by supplying from that catalogue the places of those nebulæ which had escaped his own observation. In the actual preparation of the general catalogue, which is inserted in the *Philosophical Transactions* for 1864,

Part I., considerable assistance was given by Sir George Airy, from whose suggestions the plan of calculation was adopted, the reductions having been performed, also under his superintendence, by one of the computers then attached to the Royal Observatory, the expense of which was defrayed out of a grant from the Government fund of the Royal Society. The whole of the work was subsequently examined and revised by Sir John Herschel himself. The number of nebulæ and clusters whose positions in both elements for 1860 are given amount to 5,079. For reduction to any future year, the annual precession for each object is given for 1880, and abbreviated notes, giving a summary description from a comparison of all the observations, remarks, &c.

Before Sir John Herschel had received the scientific honours awarded to him by the Royal and Astronomical Societies for his paper on revolving or binary stars, he had left the shores of England for South Africa, to carry out what had been in his mind for years, the completion of the survey of the heavens by observations in the southern hemisphere, by employing the same instruments and methods which had so successfully served their purpose in his hands in the northern hemisphere, so that a unity might be given to the results. 'Accordingly,' Sir John writes, 'having placed the instrument in question (the twenty-feet reflector), as well as an equatorially mounted achromatic telescope, of five inches aperture and seven feet focal length, by Tulley, which had served me for the measurement of double stars in England, together with such other astronomical

apparatus as I possessed, in a fitting condition for the work, and taking every precaution by secure packing, to ensure their safe arrival in an effective state at their destination, they were conveyed (principally by water-carriage) to London, and there shipped on board the 'Mount Stewart Elphinstone,' an East India Company's ship, in which, having taken passage for myself and family for the Cape of Good Hope, we joined company at Portsmouth, and sailing thence on November 13, 1833, arrived, by the blessing of Providence, safely in Table Bay on January 15, 1834, and landed the next morning, after a pleasant voyage, diversified by few nautical incidents, and without seeing land in the interim.'[1] After a temporary residence at Welterfreiden, Sir John engaged a suitable mansion, bearing the name of Feldhausen, about six miles from Cape Town; a spot charmingly situated on the last gentle slope at the base of Table Mountain. On this spot, within an enclosure—a kind of orchard surrounded on all sides by trees—a building was erected for the equatorial, while the twenty-feet reflector was mounted in the open air.

The labours of Sir John Herschel in South Africa were chiefly confined to seven different subjects of observation. The measurement of the angular distances and positions of double stars, and the observation and delineation of nebulæ were, however, the principal objects of his attention. Two of the most celebrated nebulæ in the heavens, that in the sword-handle of *Orion* and that near *η Argûs*, as well as portions of the Milky Way, have been exquisitely

[1] *Cape Observations*, Introd. p. vi.

engraved, and, as drawings, they have been acknowledged as most perfect representations of these beautiful and delicate ornaments of the southern sky. Even the nebula of *Orion*, magnificent as it is as a telescopic object in England, comes out in much grander detail in the southern hemisphere, where its great elevation in the heavens renders it comparatively free from any ill effects produced by an impure atmosphere.

The results of all this labour have been published in a large quarto volume, entitled *Results of Astronomical Observations made during the Years* 1834–1838, *at the Cape of Good Hope; being the Completion of a Telescopic Survey of the whole Surface of the Visible Heavens.* The first chapter is devoted to a discussion of his observations of the southern nebulæ and clusters of stars. They are then arranged in the form of a catalogue, the number of nebulæ and clusters being 1,707. The labour given to some of the most remarkable clusters was probably equal to that required in noting the positions of all the other nebulæ combined. One small portion of the heavens occupying scarcely more than twice of that covered by the Moon, is said to contain no less than 1,216 stars, and the observation of these was the anxious work of several months. Another, occupying only 'about one 48th part of a square degree, contains about 110 stars from the seventh magnitude downwards, eight of the more conspicuous of which are coloured with various shades of red, green, and blue, so as to give to the whole the appearance of a rich piece of jewellery.'[1]

[1] *Outlines of Astronomy*, Eighth Edition, p. 639.

The following chapters in this noble volume are devoted to detailed accounts of the observations of double stars, which are arranged as usual in a form ready for reference; to a description of the methods for determining the magnitudes or relative brightness of the stars; the probable distribution of stars in the southern hemisphere; to observations of Halley's comet, and of the satellites of *Saturn*; and, finally, to a detailed account of the solar spots visible during the latter part of 1836 and the first half of 1837. One remarkable spot which appeared on May 25, 1837, specially attracted the attention of Sir John Herschel. The black nucleus was estimated by him to be large enough to have allowed the globe of the Earth to drop through it, leaving a thousand miles clear of contact on all sides of that tremendous gulf.

The position of the twenty-feet reflector is indicated by the erection of an obelisk of Craigleith stone on the exact spot where it was mounted. The obelisk has the base six feet square and six feet in height, the pyramidal part standing twelve feet above the base. There is an opening in the east face, showing the Herschel mark, which designates the site of the reflector. An inscription is engraved on the bronze plate covering the opening. The whole was completed on February 15, 1842, in the presence of several of the subscribers, who attended to witness the placing the top stone of the obelisk.

Sir John Herschel returned with his family, which had sensibly increased during his residence at the Cape, in the spring of 1838. Writing on May 20 to his aged aunt, who had passed her eighty-eighth

year, Sir John informed her of his safe arrival in London. 'Here we are, my dear aunt, at last, safely landed and housed, all in good health, and, as you may suppose, in good spirits at our return. We ourselves and our six little ones were very comfortable during our nine weeks' voyage in the good ship 'Windsor,' which is lying snug and sound in the river at Blackwall, with all our things on board, telescopes and all (as well as the astronomical results of our expedition). We left our ship, however, at the entrance of the Channel, and got to London in a steamer under the flag of King Leopold, of Belgium, which, having been to Glasgow to take in her machinery, was returning without passengers, not yet being fitted up for their reception. This was a most opportune and unexpected piece of good fortune, as I assure you we found most sensibly, by the non-arrival of the ship till this morning, having been four days longer at sea, beating about against contrary winds. I have more particulars to tell than would fill this paper, which I must reserve till our meeting, which will not now be longer delayed than is indispensable for getting our baggage on shore, and passing it through the Custom House, and transporting it by a barge to Windsor, and so to Slough.'[1]

On the return of Sir John to England he was received by his private and scientific friends with the greatest enthusiasm. Such devotion to science as that displayed by him, from the time he left Cambridge, now a period of a quarter of a century, to the moment

[1] *Memoir and Correspondence of Caroline Herschel.* By Mrs. John Herschel. London, 1876.

when he again stepped on the shore of his native country, after four years and a half of voluntary expatriation, could not fail to reach the ears of the Government. We have already alluded to their first recognition of his services to science in 1831; and now in 1838, on the occasion of Her Majesty's coronation, he received another mark of their favour by being raised to the dignity of a Baronet. Never was an honour more worthily bestowed.

Though Sir John Herschel never resumed any long series of observations after his return from the Cape, his active mind was always employed on the discussion, either of some of his former observations, or of the various phenomena of current astronomy. At one time occupied on his second great work on the arrangement of all the nebulæ, to which we have already referred; at another time we see him investigating the variability and periodic nature of *α Orionis*, or considering the advisability of revising and rearranging the constellations. Then we have that exhaustive Memoir of the late Francis Baily, written in a style which few could excel, and delivered before the Fellows of the Royal Astronomical Society with the feelings and devotion of a friend. Later on we can recollect him joining in the controversy as to the real telescopic appearance of the markings on the solar disk, when it was a matter of opinion whether we should call them granular, or by the more definite names of willow-leaves or rice-grains. In December 1866 Sir John presented a Paper to the Royal Astronomical Society, occupying 116 pages of vol. xxxv. of the *Memoirs*, containing a synopsis of all Sir William

Herschel's micrometrical measurements and estimated positions of the double stars described by him. These Sir John has arranged in a catalogue in order of right ascension for the epoch 1880. He also contributed to the Society on January 14, 1870, his seventh and last original catalogue of double stars, observed at Slough, eighty-four of which had not been previously described. These stars would have been incorporated in his third catalogue of double and triple stars, observed with the twenty-feet reflector, if it had not been limited to stars not observed before as double, and to not more than one thousand. These additional eighty stars ought to have been included in later catalogues, but they were inadvertently passed over. The remaining stars in the seventh catalogue are made up of objects which had also been observed by W. Struve.

The last astronomical work that Sir John Herschel undertook was a further continuation of his favourite subject, consisting of the compilation into one general catalogue of all the trustworthy observations of double and multiple stars, that had been recorded in English and foreign publications. Had he been permitted to carry out his design in person, it would have been a most appropriate termination of his long and successful scientific career. But this was not to be; though in his latter years he had strength sufficient to devote a considerable portion of his time and attention to this work. He had thus gathered together observations of upwards of ten thousand double stars, all of which were arranged by him in the order of right ascension. A large portion of the manuscript was

prepared for the press, in which the approximate right ascensions and north polar distances were inserted for the epoch 1830, and the annual precessions partly filled in. But after so much was accomplished, his physical weakness gradually increased, till his hand was stayed for ever, leaving his cherished work, which he had hoped would be the crowning production of his busy life, in an unfinished state. Sir John having expressed a desire that the whole series of manuscripts should be deposited with the Royal Astronomical Society, the Council resolved that the catalogue should be completed as far as possible, and printed as a volume of the *Memoirs*. However, on a careful examination of the papers by the Editors, the late Rev. Robert Main, F.R.S., and the Rev. Professor Pritchard, F.R.S., it was found that a very large portion of the calculations was left in a very incomplete state. The intentions of Sir John were very manifest, for columns were left for the insertion of the magnitudes of the component stars, the angles of position and distances, and other data, that he evidently had not yet at hand; and more than two-thirds of the annual precessions in both elements remained to be calculated. To make the work really useful to double-star observers, it would have been necessary to insert these omitted portions; and it was at first thought that this could easily have been done. But it was soon discovered that, in the absence of the illustrious compiler, who alone knew from whence all these data were derived, the task was too heavy for any stranger to undertake to supply all that was required. Much, however, was accomplished under

the careful supervision of the Editors, including the calculation of the remaining precessions. Of the 10,280 stars of which the catalogue is composed, a synoptical history of about two-fifths of them has been preserved. The Editors remark on this point that had Sir John 'lived to complete the Synoptic History of these stars, then it might have been possible to insert the *approximate* relative positions and magnitudes of the component stars; but, under the circumstances in which the Editors were placed, they have thought it right to confine themselves, according to the intention of the Society, to those data for which they have the authority of the original manuscript.'[1] The work, as it stands, is therefore incomplete; but it will be found useful as an index-catalogue to other works on double stars, and, as such, will be valuable to astronomers.

Of the 151 papers by Sir John Herschel, whose titles are given in the Royal Society's catalogue of scientific papers, we have not referred to those relating to other sciences than astronomy, though we might have alluded with advantage to many of his researches in pure mathematics, optics, geology, chemistry and photography, and other miscellaneous subjects. Among these, his treatises on *Light* and *Sound* in the *Encyclopædia Metropolitana* ought to be specially mentioned. The article on *Meteorology* in the *Encyclopædia Britannica*, one of the most popular treatises on the subject, has been reprinted and published as a separate work. The first edition of the Admiralty *Manual of Scientific Enquiry*, prepared

[1] *Memoirs, R.A.S.*, vol. xl. p. vii.

for the use of officers in Her Majesty's Navy, and travellers in general, was edited by Sir John Herschel, by whom the article on Meteorology was contributed. Among his literary writings we ought to class his addresses on presenting the gold medal of the Royal Astronomical Society. They abound with specimens of elegant composition, several of which would be appropriate for insertion in any sketch of his scientific career. But we must confine ourselves to one well-known extract, taken from an address delivered on presenting the medal to Francis Baily on April 11, 1827, for his new tables for determining the places of 2,881 stars,[1] and having a special reference to the question, 'Of what use is the preparation of such an elaborate work as a general catalogue of stars?' 'If we ask,' says Sir John, 'to what end magnificent establishments are maintained by States and sovereigns, furnished with masterpieces of art, and placed under the direction of men of first-rate talent and high-minded enthusiasm, sought out for those qualities among the foremost in the ranks of science, if we demand *cui bono*? for what good a Bradley has toiled, or a Maskelyne or a Piazzi worn out his venerable age in watching? the answer is—not to settle mere speculative points in the doctrine of the universe; not to cater for the pride of man, by refined inquiries into the remoter mysteries of nature, to trace the path of our system through space, or its history through past and future eternities. These, indeed, are noble ends, and which I am far from any thought of depreciating; the mind swells in their

[1] Generally known as the *Astronomical Society Catalogue* (A.S.C.).

contemplation, and attains in their pursuit an expansion and a hardihood which fit it for the boldest enterprise. But the direct practical utility of such labours is fully worthy of their speculative grandeur. The stars are the landmarks of the universe; and, amidst the endless and complicated fluctuations of our system, seem placed by its Creator as guides and records, not merely to elevate our minds by the contemplation of what is vast, but to teach us to direct our actions by reference to what is immutable in His works. It is, indeed, hardly possible to over-appreciate their value in this point of view. Every well-determined star, from the moment its place is registered, becomes to the astronomer, the geographer, the navigator, the surveyor, a point of departure which can never deceive or fail him,—the same for ever and in all places, of a delicacy so extreme as to be a test for every instrument yet invented by man, yet equally adapted for the most ordinary purposes; as available for regulating a town clock as for conducting a navy to the Indies; as effective for mapping down the intricacies of a petty barony as for adjusting the boundaries of Transatlantic empires. When once its place has been thoroughly ascertained and carefully recorded, the brazen circle with which that useful work was done may moulder, the marble pillar totter on its base, and the astronomer himself survive only in the gratitude of posterity; but the record remains, and transfuses all its own exactness into every determination which takes it for a groundwork, giving to inferior instruments—nay even to temporary contrivances, and to the observations of a few weeks or

days—all the precision attained originally at the cost of so much time, labour, and expense.'[1]

It was not by his papers on double stars or nebulæ, nor even by his carefully written and elegant addresses, delivered at the meetings of scientific Societies, that Sir John Herschel obtained that universal popularity as an astronomical writer which he enjoyed long before he attained the meridian of life. It was rather through the success of his elementary books on Science, written expressly as aids to the student, that the great scientific reputation of the author was made outside the precincts of those learned bodies where the results of his labours had been already received with so much honour. His classical work, a *Preliminary Discourse on the Study of Natural Philosophy*, which appeared in 1833, was perhaps the first of his popular books which gained for him the applause of the general public. The student, while adding to his knowledge by the careful perusal of such a book, could hardly fail to be enraptured with the style of its composition, and to become absorbed in the consideration of the sublime sciences which form the subjects of its contents. This *Discourse* was one of the volumes of Dr. Lardner's *Cabinet Cyclopædia*—a most valuable series of standard works on history, biography, science, and moral and political philosophy, by authors of the highest repute as the leaders of thought. Sir John Herschel contributed a second work to this series on his own peculiar science. In this he succeeded in laying before the reader most lucid explanations of the various motions and phy-

[1] *Monthly Notices, R.A.S.*, vol. j. pp. 15, 16.

sical constitutions of the heavenly bodies, with that perspicuity which is so perceptible in all his printed works. The success of this little treatise was so complete that Sir John was induced to prepare a more extended but still popular work on astronomy, using his former volume as the groundwork of his new treatise. Thus originated his far-famed *Outlines of Astronomy:* an exposition of all that is peculiar in the motions of the different members of the solar system, and of the probable distribution of the vast starry universe beyond it. One great beauty in the character of the *Outlines* is, that it contains the original and mature thoughts and experiences of this celebrated observer, who had been such an active devotee to his favourite science throughout his life; for we know that from the very earliest days of childhood he was enveloped in the atmosphere of astronomical research. This very popular work has passed through a large number of editions; and it still holds a foremost place among the many treatises on astronomy, as an original, clear, and accurate exposition of the laws of the solar system, and of the stellar universe that surrounds us.

The subjects specially treated in this well-known work may be briefly stated to include the general motions of the Earth; the phenomena of refraction and parallax; astronomical instruments and their methods of use; the form and dimensions of the Earth; the Sun's motion and physical constitution; the Moon; the law of universal gravitation; the solar system; comets; the lunar and planetary perturbations, &c.; sidereal astronomy; clusters of stars

and nebulæ; and chronology. It also contains synoptic tables of the elements of the orbits of the different members of the planetary systems.

In his later years, Sir John Herschel contributed some excellent articles to *Good Words*, all bearing internal evidence of the master-mind of the writer. These were afterwards collected, and, with others, they form an attractive volume of popular science, under the title of *Familiar Lectures on Scientific Subjects*. The first three articles—on Earthquakes and Volcanoes, on the Sun, and on Comets—were originally prepared for a course of parish lectures, delivered in the school-house at Hawkhurst, in Kent, to his fellow parishioners. The remainder are on various subjects—as, the weather, celestial measurings and weighings, light, on the origin of force, &c. Some of these appear difficult in name; but, from the clear and simple explanations of the great astronomer, few readers could close the book without having gathered some knowledge of the phenomena which he describes.

Sir John Herschel shone not only as one of the lights of science, but he was also a poet of no mean order. In his volume of *Essays*, published in 1857, may be found some of his effusions of fancy, which might well rival those of some of our standard poets. His friend, Professor Pritchard, referring to him in this light, writes: 'For John Herschel was a poet in a high sense, and of science he was emphatically *the* poet. Without imagination no man can become a truly great philosopher, and still less a truly great writer; and Herschel was both: and hence with him,

as with many other of our ablest mathematicians, versifying became a solace and a recreation from severer work. There are passages in some of these little poems, and there are lines in his more formal translation of the *Iliad*, published at a much later period, which plainly indicate that, had he chosen to make poetry the occupation of his life, he must have occupied a conspicuous place among the poets of his age.'[1] We give the following Sonnet composed on the occasion of his visiting the Cathedral at Ely, with his friend the late Sir William Hamilton, F.R.S., formerly the Astronomer Royal for Ireland :—

Sunday, July 29, 1845.

The organ's swell was hushed,—but soft and low,
An echo more than music rang,—where he,
The doubly-gifted, poured forth whisp'ringly,
High-wrought and rich, his heart's exuberant flow,
Beneath that vast and vaulted canopy.
Plunging anon into the fathomless sea
Of thought, he dived where rarer treasures grow,
Gems of an unsunned warmth, and deeper glow.

Oh ! born for either sphere, whose soul can thrill
With all that Poesy has soft or bright,
Or wield the sceptre of the sage at will,
(That mighty mace which bursts its way to light),
Soar as thou wilt, or plunge,—thy ardent mind
Darts on—but cannot leave our love behind.

In the year 1850 Sir John Herschel was appointed Master of the Mint, which from that time became a permanent and non-political office. It is remarkable that the first of English mathematicians, Sir Isaac Newton, held the same appointment. Sir John

[1] *Monthly Notices, R.A.S.*, vol. xxxii. p. 139.

Herschel, however, does not appear to have been in his element in this official position; moreover, the time had arrived when reforms were introduced into the establishment, some of which were not altogether palatable to his sensitive nature; the result being that, after five years' service, he retired in 1855 into his usual calm and unobtrusive private life. His health, however, had not been good for some time previous to his retirement, and his friends felt great uneasiness as to the result. Having cast off official care, he was, however, soon restored to his usual health; but it was remarked that he never again took an active part in the business of the Societies of which he was a member, nor was he of late years even an occasional attendant at their meetings. He preferred to spend his remaining years in the quiet retirement of his chosen residence in one of the most beautiful districts in Kent, where he was free to follow out the bent of his inclinations in the interests of science. That his time was well spent, we have abundant evidence in the numerous contributions to astronomy which have emanated from his secluded study. He was ever ready to carry on a correspondence with his friends on scientific matters, and to give advice to those who sought the opinion of so experienced a master.

As might be expected, Sir John Herschel was frequently called upon to serve on scientific Committees, Boards, or Royal Commissions. Of these we need only refer to two—one of which was a permanent, the other a limited appointment. He was one of the oldest members of the Board of Visitors of the

Royal Observatory, which meets annually on the first Saturday in June, to receive a Report from the Astronomer Royal, and to inspect the instruments and work carried on there during the preceding twelve months. No one took a greater interest in the prosperity of the national centre of astronomy than Sir John Herschel; and, when his health permitted, he was always present at the Board. He was also an important member of the Royal Commission on Standards, appointed to prepare new standards of length and weight, in lieu of the originals destroyed in the fire at the Houses of Parliament in 1834. This Commission remained in existence several years, and was presided over by the present Astronomer Royal, Sir G. B. Airy, F.R.S.

Though Sir John Herschel preferred the quietness of country life during his later years, he was at an earlier date much sought after to fill some of the most important offices in the principal learned Societies. He was a member of the Council and one of the Secretaries of the Royal Society for years; and in 1830, under peculiar circumstances, he was proposed as President of that Society. On the resignation of Mr. Davies Gilbert, M.P., F.R.S., one half of the Fellows, who may be termed the Court Party, supported the nomination of the Duke of Sussex, F.R.S., as his successor; the other half, which may in like manner be termed the Scientific Party, preferred to have an acknowledged philosopher at their head. There were, however, special reasons at that time which influenced many of the Fellows, who privately would have rejoiced to see Sir John elected, to

support a popular member of the Royal Family; but, though these reasons were urged most strongly in favour of the Duke of Sussex, he succeeded only by eight votes, two hundred and forty Fellows being present. On a subsequent occasion Sir John was unanimously requested to accept the Presidency, but he declined. In the Royal Astronomical Society he had served the offices of Secretary and President—the latter on three separate occasions. He was for many years also an honoured member of the Council. His name is likewise enrolled among the past Presidents of the British Association for the Advancement of Science, Sir John having presided over the meeting at Cambridge in 1845. Of foreign Societies he was an honorary member of so many, that the reader is referred to the title-page of his *Outlines of Astronomy* for a list of some of them. One of these, however, we do not hesitate to mention as perhaps the highest scientific honour ever conferred; and when we say that Sir John was one of the eight Foreign Members of the Institute of France, we are classing him among the greatest of the living philosophers of his time.

Though the death of Sir John Herschel was not unexpected, still it came upon us all with startling suddenness. The public papers gave eulogistic notices of his life and works; his loss to science was universally deplored; and we all felt that a great man had passed away, who had for more than half a century been one of the leading lights of science. He died at his residence, Collingwood, near Hawkhurst, on May 11, 1871, having in the previous March completed the seventy-ninth year of his age. His funeral

took place on Friday, May 19, at Westminster Abbey, where all that was mortal of him was placed by the side of Newton. The scene was one of great solemnity, and can never be forgotten by those favoured few of us who in duty followed his remains along the sacred pavement of the Abbey to the spot selected as his last earthly home. It was difficult to control our emotions as the beautiful Service for the Dead was read so impressively by Dean Stanley at the grave, and as the words of Handel's anthem 'His body is buried in peace, but his name liveth evermore,' was sung by the attendant choir. And then as we gazed down on the coffin for the last time, with the symbol of the Christian religion lovingly placed on it, we felt that our friend, although all that was mortal was lying there, would still live in the remembrance of his countrymen, and that by his works we shall truly be able to say, that 'he being dead, yet speaketh.'[1]

Sir John Herschel married in 1829 Margaret Brodie, daughter of the Rev. Alexander Stewart, D.D., by whom he had a large family, of whom three sons and eight daughters were surviving at the time of his death. His three sons are:—

1. *Sir William James*, the present Baronet, of the Bengal Civil Service, born in 1833.
2. *Alexander Stewart*, F.R.A.S., Professor in the College of Physical Science, Newcastle-on-Tyne, born in 1836.
3. *John*, Major, Royal Engineers, F.R.S., F.R.A.S.,

[1] The author was present as one of the Honorary Secretaries of the Royal Astronomical Society.

Deputy Superintendent, Great Trigonometrical Survey of India, born in 1837.

The following inscription is engraved on the pavement over the grave of Sir John Herschel in Westminster Abbey:[1] —

JOANNES HERSCHEL
GULIELMI HERSCHEL
NATU OPERE FAMA
FILIUS UNICUS
"CŒLIS EXPLORATIS"
HIC PROPE NEWTONUM
REQUIESCIT

GENERATIO ET GENERATIO
MIRABILIA DEI NARRABUNT
PSALM CXLV. 4, 5.

VIXIT LXXIX. ANNOS
OBIIT UNDECIMO DIE MAII
A.D. MDCCCLXXI.

[1] It was the intention of the relatives of Sir John Herschel to bury him with his father in the parish church of St. Laurence, Upton; the vault containing the remains of Sir William was therefore opened for the reception of the body, before permission was given for its interment in Westminster Abbey.

SIR WILLIAM HERSCHEL, K.C.H., F.R.S.

1738–1822.

WHEN a seventh primary planet was unexpectedly discovered by William Herschel in 1781, and its planetary nature decided, scientific men of all nations hastened to offer their congratulations to the gifted musician of Bath. To be the means of adding another major planet to the known members of the solar system, was indeed a great personal honour for an amateur astronomer, especially when it was universally believed by all educated men that *Saturn* was the boundary planet of the system; and when no one could have conceived that the space between the orbits of *Mars* and *Jupiter* is occupied by at least 191 asteroids, and probably by very many more. Many can remember the excitement which followed the great triumph of intellect in 1846, which led to the marvellous detection of *Neptune*; but even this discovery hardly produced so great a sensation in the popular mind as that which followed the announcement of the existence of *Uranus*. Before this planet was observed by him in 1781, William Herschel was already known as a zealous astronomer; but his public reputation in the science as a successful observer really dates from the year of this important discovery,—an event sufficient of itself to foreshadow a prediction

that he would become illustrious as one of the foremost of astronomers. We all know now that this great observer only anticipated by a few years what would doubtless have taken place long before this time, and that his detection of *Uranus*, first believed by him to be a comet, was purely accidental. This possibility of what others might have done, does not, however, detract in the smallest possible degree from the observing acuteness and skill of William Herschel, for the present generation of astronomers continue to look to him as the great and original pioneer of modern planetary discovery. Could he have imagined that, before one hundred years had passed away, the known planetary members of the solar system would have been increased from seven to more than two hundred, by far more difficult methods of searching than that to which he was accustomed, he would himself have probably concurred in the belief that his success was due to one of those fortunate accidents which frequently occur in every branch of scientific, as well as daily, life.

WILLIAM HERSCHEL, or, more correctly, Frederic William, was born at Hanover on November 15, 1738. He was the fourth child of Isaac Herschel and Anna Ilse Moritzen, for many years resident in that city. His father, who died in March 1767, was descended from a Moravian family, and was an eminent musician attached to the Court orchestra, and hautboy player in the band of the Hanoverian Guards. The limited means of Isaac Herschel prevented him giving his ten children any general education[1] except that which

[1] It is remarkable that all Isaac Herschel's children, of whom we

could be obtained at the garrison school, where William showed himself to be an apt pupil, not only in the elementary subjects, but also in French and Latin. At fourteen the future astronomer was a skilful player on the oboe and viol, and, with his brothers, he soon got occasional employment in the Court orchestra. At seventeen he had already a strong predilection for philosophical pursuits, thus described by his sister Caroline in her *Recollections*: 'Generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary, when the names Leibnitz, Newton, and Euler sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and frequently it happened that when he stopped for an assent or reply, he found his hearer (his eldest brother Jacob) was gone to sleep; and I suppose it was not till then that he bethought himself to do the same. The recollection of these happy scenes confirms me in the belief, that had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My father was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me, on a clear frosty night, into the street to

have any record, were accomplished musicians. Four died in early childhood.

make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly turned four-inch globe, upon which the equator and ecliptic were engraved by my brother.'[1]

At the end of 1755 William Herschel, with his eldest brother Jacob, joined the band of the Guards, which about that time was ordered to England. He returned to Hanover with his father, his brother having preceded them, in the following year; but after the disastrous battle of Hastenbeck, near Hanover, on July 26, 1757, in which the French were victorious, William Herschel retired from the band, his physical strength not being equal to stand the hardships of war. He soon afterwards revisited England, in company again with his brother Jacob, with the intention of making it his adopted home. His brother, however, returned to Hanover in 1759. During the first few years of his residence in England the history of William Herschel is involved in much obscurity; but it is believed that his musical talents were not sufficiently known to prevent him undergoing considerable personal privations, though he never gave himself up to despair. While thus apparently uncared for, Lord Durham obtained for him the office of instructor in music to an English regiment stationed in the northern counties. This appointment soon brought him into

[1] *Memoir and Correspondence of Caroline Herschel*, by Mrs. John Herschel, pp. 7 and 8.

notice, and his reputation as a skilful musician gradually increased till it ultimately led to more permanent employment. In 1764 he paid a short visit to Hanover, to the great joy of his family.

William Herschel's fame as an accomplished musician was becoming known throughout England, not only as a skilful player, but as a composer of anthems, chants, overtures, &c., when he accepted the position of organist at Halifax, the stipend of which, together with the fees derived from private tuition, placed him at last in comparatively easy circumstances. He now felt a strong desire to improve his education, and most of his leisure-time was devoted to reading Smith's Theory of Music, and to the study of languages, particularly of Latin and Italian, and a little Greek, with no other assistance than his grammars and dictionaries. He soon, however, attained a considerable proficiency in each language.

In the year 1766 William Herschel obtained the more lucrative appointment of organist at the Octagon Chapel, at Bath. During the early part of his residence there his time was much taken up in public miscellaneous musical services, in addition to his attendance on a large number of private pupils; yet he still found opportunities for continuing his study of languages and mathematics with success. Sir William Herschel never attained the rank of a mathematician of the first order, but the original talent shown in his writings proves that he possessed a strong mathematical mind. Those who have had occasion to examine his numerous published papers must have noticed a clearness of perception pervading

all his researches; from which we may reasonably assume that, had he received a special training in the exact sciences, his attainments and power of mathematical application would have been second to none. The constancy and determination he exhibited while pursuing step by step those self-taught acquirements which marked the successive portions of his early career, have been dwelt upon by different writers. M. Arago, in his sketch of the life of Sir William Herschel, says: 'It was through music that Herschel was led to the study of mathematics; mathematics in their turn conducted him to optics, the principal and fruitful source of his successful career. At last the time came when his theoretical knowledge was sufficient to guide the young musician into a laborious application of principles completely foreign to his habits; and of which the brilliant success, as well as the boldness of his conceptions, justly excites astonishment.'

In 1772 William Herschel again visited his native place; but his principal object was to accompany his sister Caroline, whom he persuaded to become his companion and fellow-worker, and 'for ten years she persevered at Bath, singing when she was told to sing, copying when she was told to copy, "lending a hand" in the workshop, and taking her full share in all the stirring and exciting changes by which the musician became the King's astronomer and a celebrity.' The brother and sister left Hanover on August 16, and arrived at his residence, 7 New King Street, Bath, on August 28.

The effect of William Herschel's mathematical

studies was soon apparent by the increased interest he took in the observation of astronomical phenomena; but, at this time of his life, he could not have foreseen that in a few years his reputation as a teacher of music would be almost forgotten, and that his name would be honoured throughout the civilised world as that of a successful philosopher and astronomer. Many years before he was heard of in astronomy, he possessed a strong inclination to examine for himself the peculiarities presented by the different planets, but his limited means prevented him from purchasing a telescope. However, shortly after he had commenced residence at Bath, a small telescope of two-feet focal length came into his possession. This instrument, imperfect as it was, was sufficiently good to exhibit many objects invisible to the naked eye. The first examination of the heavens with this telescope created the utmost enthusiasm in the young musician-astronomer's mind; and he determined, therefore, to acquire another telescope, but of greater aperture and magnifying power. He again found, on inquiry, that the price demanded by the optician was too excessive for his simple pecuniary resources. This disappointment would have been sufficient to damp the ardour of most young astronomers; but in William Herschel it only increased his determination to obtain what he desired. As he could not purchase a telescope, he resolved to construct one with his own hands. He now devoted all the time he could spare to experiments in order to procure the best metallic alloy for reflecting light, and on the polishing apparatus for giving the exact figure to the speculum. So

determined a perseverance was certain to be rewarded. In 1774 William Herschel had the satisfaction of examining the heavens with a Newtonian telescope of five-feet focal length, constructed entirely by himself.

The leisure hours of William Herschel were from this time fully occupied in these mechanical labours, in which he was assisted by his brother Alexander, who was both an excellent musician and mechanician. During his residence at Bath a great number of Newtonian reflecting telescopes were made, varying from two feet to twenty feet in length, besides several others of the Gregorian form. It was his usual custom to select by trial, from the numerous specula which he was constantly casting, those only sensibly perfect in form. These were preserved, while the remainder were at once laid aside, either to be recast or re-polished. In this manner the two brothers made no less than 430 mirrors of different sizes—200 of seven feet, 150 of ten feet, and about 80 of twenty feet focal length, without including those for the Gregorian telescopes.

William Herschel's great success in constructing reflecting telescopes gradually led him onward to attempt one of larger dimensions. He therefore, in the year 1781, commenced a reflector of thirty-feet focal length. After having invented a stand for it, of a novel design, he cast the speculum, which was three feet in diameter. The composition of the metal being too brittle, the speculum cracked while cooling. It was then recast; but a second accident, arising from the furnace giving way, caused all the metal to run

into the fire. These unlooked-for interruptions put a temporary stop to Herschel's attempts at constructing a reflecting telescope of large dimensions. As the novel discovery of a new planet, and his subsequent change of residence, fully occupied his thoughts for the next few years, the object he had in view was postponed to a more favourable opportunity.

Though William Herschel succeeded so well as a maker of reflecting telescopes, for which a constant demand had sprung up, he never ceased to labour in his profession as a performing musician and private teacher of music, even during his last year's residence at Bath. His pupils were mostly ladies, to whom he was accustomed to give weekly from thirty-five to forty musical lessons. But for some time there had been evident signs that he was gradually becoming eminent as a practical astronomer, and that his inclination for public musical performances was diminishing; though in the winter of 1781–2, he conducted a series of oratorios at Bath, as had been his custom for several years. When, however, he startled the scientific world by his discovery of *Uranus*, followed soon after by his removal to Datchet, he retired from the active pursuit of his profession as a teacher of music, and devoted himself principally to astronomical observation and research, or to the construction of telescopes as a matter of business. Before leaving Bath he commenced the plan of observation, which he afterwards systematically continued, of examining successively different portions of the heavens, and of recording the features of all phenomena that appeared to him in any way remarkable. It was while occupied

in this manner, using one of his best telescopes, that he noticed, in the constellation *Gemini*, a star whose light shone with a very marked difference of lustre to those of similar magnitude around it; and, though the magnifying power used was not very great, it was sufficient to exhibit the image of the object with a disk. On examining it with a higher power, its diameter was found to have visibly increased, which was not the case with any other star near it. Herschel at once assumed that he had discovered a comet; and in a few days he found that it had changed its position with respect to the stars, but that its daily motion was very slow. He lost no time in communicating his discovery to Dr. Maskelyne, then the Astronomer Royal, who, having examined it himself at the Royal Observatory, sent information of the circumstance to the astronomers at the Paris Observatory. The supposed comet was observed for some months, and attempts were made to calculate its orbit, assuming that it was one of these errant members of the solar system. Eventually, however, its true nature began to be suspected; and, as the orbit was found to be nearly circular, all doubts were soon set at rest, and astronomers thus became aware of the fact that the suspected comet of Herschel was truly an additional member of the solar system. The date when Herschel detected the new planet was March 13, 1781.[1] The Royal Society in the same year awarded him the Copley Medal for his 'discovery of a new and singular star.' He was also elected a Fellow of the Society on December 6, 1781. It is remarkable that so long a

[1] The discovery was communicated to the Royal Society on April 26.

period elapsed before the new star was identified as a planet; and it was not till November 7, 1782, or nearly two years after its discovery, that Mr. Herschel felt himself justified in giving it a name. A letter from him to the President, Sir Joseph Banks, was read at the meeting of the Royal Society, held on the above day, in which he gives his reasons for selecting the name of *Georgium Sidus*.[1] This name was not acceptable to foreign astronomers, especially to the Germans, who preferred to keep to the usual mythological nomenclature. The French astronomers, however, proposed the name of *Herschel*, in honour of the discoverer; but, in the end, the name of *Uranus* was adopted in all countries by universal consent.

By this great discovery, the attention of the King was drawn to the astronomer of Bath. In May 1782 William Herschel had an audience of his Majesty, to whom he presented a drawing of the solar system,

[1] The following is a copy of the letter: 'By the observations of the most eminent astronomers in Europe, it appears that the new star, which I had the honour of pointing out to them in March, 1781, is a primary planet of our solar system. A body so nearly related to us by its similar condition and situation in the unbounded expanse of the starry heavens, must often be the subject of the conversation, not only of astronomers, but of every lover of science in general. This consideration, then, makes it necessary to give it a name, whereby it may be distinguished from the rest of the planets and fixed stars. In the fabulous ages of ancient times the appellations of Mercury, Venus, Mars, Jupiter, and Saturn, were given to the planets, as being the names of their principal heroes and divinities. In the present more philosophical era, it would hardly be allowable to have recourse to the same method, and call on Juno, Pallas, Apollo, or Minerva for a name for our new heavenly body. The first consideration in any particular event, or remarkable incident, seems to be its chronology: if in any future age it should be asked—*when* this last-found planet was discovered? it would be a very satisfactory answer to say—in the reign of King

and had the honour of explaining it to him and the Queen. On the evening of July 2, he again was summoned by the King to exhibit one of his telescopes, and, the weather being fine, great satisfaction was given; and in a letter to his sister he remarked that 'the King has very good eyes, and enjoys observations with telescopes exceedingly.' The result of these interviews was that he received the private appointment of Royal Astronomer, with a salary of £200 a year. On August 1, 1782, the Herschels took up their residence at Datchet, near Windsor, 'where he had taken a house, with a garden and grass-plot annexed, quite suitable for the purpose of an observing-place.' In 1785, however, they removed to another residence, Clay Hall, Old Windsor; but on April 3, 1786, the house at Slough, which continued to be the home of Sir William to the end of his life, was taken, and all the apparatus removed there immediately. Herschel employed his last night at Clay

George the Third. As a philosopher, then, the name of GEORGIUM SIDUS presents itself to me as an appellation which will conveniently convey the information of the time and country where and when it was brought to view. But, as the subject of the best of Kings, who is the liberal protector of every art and science;—as a native of the country from whence this illustrious family was called to the British throne;—as a member of that Society which flourishes by the distinguished liberality of its Royal Patron;—and, last of all, as a person now more immediately under the protection of this excellent monarch, and, owing everything to his unlimited bounty,—I cannot but wish to take this opportunity of expressing my sense of gratitude, by giving the name Georgium Sidus—

Georgium Sidus
—jam nunc assuesce vocari.—VIRG. *Georg.*

to a star, which (with respect to us) first began to shine under his auspicious reign.'—*Phil. Trans.*, 1782.

Hall sweeping for stars, and before dark on the following evening the telescope was remounted at Slough, ready to continue the observations.

In 1783 William Herschel constructed a twenty-feet reflector, which he mounted in a manner very similar to that afterwards adopted by him for his celebrated forty-feet telescope. After two years' observation with it, he was so impressed with the great advantage derived by the use of large mirrors for special observations, that he resolved to renew his attempts at casting a speculum of larger size. Encouraged by his former experience, he consulted the President of the Royal Society, in order to devise some means of obtaining the necessary funds. Sir Joseph Banks undertook immediately to lay the project before the King, who was not only pleased with the proposition, but offered to bear all the expenses incidental to the construction of such a telescope. Preparations were at once begun, the casting of the great four-feet mirror was successfully accomplished, and the final completion of the instrument, without any serious mishap, was announced on August 28, 1789, in the form so well known by the numerous drawings and engravings of it in popular works on astronomy.[1] The following extract gives an interesting account in Dr. Herschel's own words of the construction of this renowned telescope:—

'I began to construct the forty-feet telescope about the latter end of 1785. The wood-work of the stand and machines for giving the required motions

[1] A very good representation of this telescope is given in the author's *The Midnight Sky*, p. 210.

to the instrument were immediately put in hand, and forwarded with all convenient expedition. In the whole of the apparatus none but common workmen were employed; for I made drawings of every part of it, by which it was easy to execute the work, as I constantly inspected and directed every person's labour; though sometimes there were not less than forty different workmen employed at the same time. While the stand of the telescope was preparing, I also began the construction of the great mirror, of which I inspected the casting, grinding, and polishing; and the work was in this manner carried on with no other interruption than what was occasioned by the removal of all the apparatus from Clay Hall, where I then lived, to my present situation at Slough. Here, soon after my arrival, I began to lay the foundation upon which by degrees the whole structure was raised as it now stands; and the speculum being highly polished and put into the tube, I had the first view through it on February 19, 1787. I do not, however, date the completion of the instrument till much later.'[1] By the mismanagement of the person who cast the mirror, it was found too weak to permit a good figure being given to it; a second mirror was cast, but it cracked in cooling; this was recast a few weeks afterwards with success, and before the end of the year 1788 it was brought to a pretty good figure and polish. Dr. Herschel, however, was not satisfied with his mirror till August 28, 1789, when he discovered with it the sixth satellite of *Saturn*, and saw the spots on that planet better than he had ever seen

[1] *Phil. Trans.*, 1795, vol. lxxxv.

them before. He then announced the completion of the telescope. The entire cost of the instrument was about £4,000. Miss Herschel, in a letter to Lady Herschel, dated January 10, 1840, wrote that 'before the optical parts were finished, many visitors had the curiosity to walk through it, among the rest King George III.; and the Archbishop of Canterbury, following the King, and finding it difficult to proceed, the King turned to give him the hand, saying, "Come, my Lord Bishop, I will show you the way to Heaven!" This was in the year 1787, August 17, when the King and Queen, the Duke of York, and some of the Princesses were of the company.'[1]

This ever-memorable instrument was mounted on a platform revolving in azimuth on a series of rollers. Four ladders, united together at the top by being bolted to a cross-bar, served as a framework for the support of the telescope, and a convenient means of approaching the exterior opening of the great tube. The pulleys, by which the telescope was either raised or lowered, were fixed to this cross-bar, as well as another set by which the balcony where the observer stood, to enable him to look down the tube, was also raised or lowered. These pulleys were each worked by a windlass on the platform. The framing was strengthened by another system of diagonal ladders, and by several masts and braces. The telescope tube was thirty-nine feet four inches in length, and its clear diameter four feet ten inches. It was constructed entirely of iron. The principal mirror was four feet in diameter, and contained 1,050 lbs. of metal. This

[1] *Memoir etc. of Caroline Herschel*, p. 309.

great speculum, which had a reflecting surface of about twelve and a half feet, was placed at the lower end of the tube, the apparatus for adjusting it being protected by a small wooden building. The axis of the speculum, when placed in the tube, was so inclined as to allow its focal point to fall at about two inches from the lower end of the upper mouth of the tube, so that the observer, standing in the balcony, was enabled to direct an eye-piece, fixed in a convenient position, upon the image of the object formed by reflexion on a small mirror adjusted to the focus of the large speculum. To make an observation, three persons were always required: the observer, who stood in the balcony at the mouth of the tube, an assistant to record the observations in a book or on a slate, a third person being required to work the windlass when the telescope had to be directed to any particular object.[1]

This celebrated and popular instrument, which had done such excellent service in the cause of astronomical discovery, was dismantled in December 1839. On the return of Sir John Herschel from South Africa in 1838, he found that during his absence the wood of the framework had become so much decayed in some of its most important parts, as to become absolutely dangerous. He therefore resolved to take the instrument to pieces, and to preserve the metal-work on the spot as a memento of the old telescope. The framework having been cleared away, piers were erected, on which the tube was placed in a horizontal position. Inside the tube the mirror, and all the important

[1] *Phil. Trans.*, 1795, vol. lxxxv.

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parts of the machinery and polishing apparatus were placed, and the end of the tube was then closed up.[1] Before, however, this was done, the Herschel family held a jubilee meeting on New Year's Eve within the tube, at which the following requiem song, composed by Sir John Herschel, was heartily sung by 'Papa, Mamma, Madame, and all the little bodies in the tube thereof assembled.' An original copy of this ballad is preserved in the library of the Royal Observatory, printed as a broadside.

In the old Telescope's tube we sit,
And the shades of the past around us flit;
His requiem sing we, with shout and with din,
While the old year goes out, and the new one comes in.

Chorus of youths and virgins.
Merrily, merrily, let us all sing,
And make the old Telescope rattle and ring.

Full fifty years did he laugh at the storm,
And the blast could not shake his majestic form;
Now prone he lies, where he once stood high,
And searched the deep heavens with his broad bright eye.
Merrily, merrily, etc.

There are wonders no living wight hath seen,
Which within this hollow have pictured been;

[1] In a foot-note on p. 310 of the *Memoir etc. of Caroline Herschel*, it is stated that the great mirror is now put up in the hall of the house at Slough. We have lately been informed that other remains of the machinery and tube are still preserved in the garden; and that, where the great forty-feet reflecting telescope stood, a new parish church has been erected. A beautiful design for a proposed spire, to be called the Herschel spire, in memory of the great astronomer, was exhibited at the Royal Academy a year or two ago by Mr. John Scott. The local authorities are waiting for some encouragement from astronomers before proceeding to erect this appropriate memorial on the spot consecrated by Sir W. Herschel's labours.

Which mortal record can ne'er recall,
And are known to Him only who makes them all.
Merrily, merrily, etc.

Here watched our father the wintry Night,
And his gaze hath been fed with pre-Adamite light;
While planets above him in mystic dance
Sent down on his toils a propitious glance.
Merrily, merrily, etc.

He has stretched him quietly down at length,
To bask in the starlight his giant strength;
And Time shall here a tough morsel find,
For his steel-devouring teeth to grind.
Merrily, merrily, etc.

He will grind it at last, as grind it he must,
And its brass and its iron shall be clay and dust;
But scatheless ages shall roll away,
And nurture its frame in its form's decay.
Merrily, merrily, etc.

A new year dawns, and the old year's past,
God send us a happy one, like the last,
A little more sun, and a little less rain,
To save us from cough and rheumatic pain.
Merrily, merrily, etc.

God grant that its end this group may find
In love and in harmony fondly joined;
And that some of us fifty years hence, once more,
May make the old Telescope's echoes roar.

Chorus, fortissimo.
Merrily, merrily, let us all sing,
And make the old Telescope rattle and ring.

With this forty-feet reflecting telescope every celestial object at which it was directed was exhibited under a very different aspect from that previously known; in fact, the heavens had never been scanned

by such a powerful telescope before. A considerable number of the nebulæ which had hitherto appeared in the usual gaseous form were resolved into a multitudinous number of stars; others, again, which had been scarcely perceptible, became now distinctly visible; and a vast number, hitherto unknown, were discovered through the increased penetrating power possessed by this great telescope. The physical constitution of nebulæ became much more understood from the observations of Dr. Herschel; and till the construction of the Earl of Rosse's great reflecting telescope at Parsonstown, and the publication of Sir John Herschel's beautiful delineations of some of the principal nebulæ, our knowledge of these faint objects chiefly depended on the descriptions and speculations of the elder Herschel. It is not to be wondered at that many of his ideas respecting the origin and composition of nebulæ have been overruled by the observations of modern days, or since the analysis of their light has been so successfully made by means of the recent application of the spectroscope, as an aid to the telescope, in researches of this nature. Be this as it may, to Sir William Herschel is due the honour of having led the way to our present improved conceptions of the character of nebulæ, by chronicling assiduously so much relating to them when the subject was new.

While the construction of the forty-feet telescope was in progress, Mr. Herschel received the greatest honour usually conferred by our Universities on leading scientific men. In becoming a Doctor of Laws of the University of Oxford, which was conferred on him in

1786, Dr. Herschel received a well-deserved recognition of his eminent services by that great academic body who are ever ready to bestow their honorary degrees on those who, by their works, are prominent leaders in literature and science.

The observations of Sir William Herschel were so numerous and varied in their character that it would be foreign to our purpose if we gave even the shortest abstract of his sixty-nine Papers, communicated to the Royal Society, for it would almost require a volume to give even an epitome of his different researches. It may be remarked, however, that most of his discoveries have been confirmed by the observations of later astronomers, and that the general results of his investigations have been received with the greatest respect. It must be understood that Sir William Herschel's great reputation rests in some measure on his systematic sweepings for new objects, in which he was so successful in fixing their approximate positions, and not on the determination of the accurate positions of the celestial bodies, which, as a rule, is left for the astronomers at the public observatories to do. His principal instruments were of great penetrating power, and, in his hands, they became the means by which the heavens were gauged for new objects as they never were before; and thus their constructor had the pleasure of receiving due homage in his lifetime as the prince of gazing astronomers.

From these few general remarks, we have only a faint conception of the numerous subjects of observation which occupied the attention of Sir William Herschel during his nightly watches. We can, how-

ever, obtain a fair notion of his labours by casting a glance over the titles of his different investigations and observations, contained in the Index to the *Philosophical Transactions*. To accumulate such a mass of details of nebulæ and double stars, as we see recorded there, must have occupied a large portion of his observing time; and only those who know what the reduction of observations means can fully appreciate the heavy labour which must have afterwards fallen upon Dr. Herschel and his sister before any results could have been communicated to the outer world. The habits at this time of both brother and sister seemed to require observing at night on every available opportunity, and computing or copying by day, so as to place in order for ultimate publication what had been observed. Among his many investigations, that relating to the movement of the solar system in space, read before the Royal Society in 1783, strikingly exhibits the originality and power of his mind.

His first published paper in the *Philosophical Transactions* of the Royal Society for 1780 is on observations of the periodical star *Mira Ceti*; but if we take the solar system as an example of the subjects to which Sir William Herschel devoted much of his attention, we shall soon have an idea of the character of astronomical research which occupied the days and nights of this indefatigable astronomer, independently of his ordinary sweepings for double stars and nebulæ. So early as 1777 he was investigating the rotation of *Venus*; then in 1781 two papers were read before the Royal Society, one containing observations of the rotation of the planets generally round their axes,

with a view to determine whether the Earth's diurnal motion is perfectly equable; and the second gives an account of his discovery of a supposed comet, which turned out to be the planet *Uranus*. In 1781 and 1784 some important discoveries are recorded in two memoirs relating to the remarkable appearances of the polar regions of the planet *Mars*, the inclination of, and rotation round, its axis, the position of its poles, etc. He also obtained some interesting results on the axial rotation of *Jupiter*, and of the comparative magnitude of its satellites. Soon after the completion of the great forty-feet reflector, he published a very important memoir on *Saturn*, with remarks on the construction of its rings, its atmosphere, its rotation on its axis, and its spheroidal figure. This memoir also contains an account of the discovery of two additional satellites of extreme faintness; one, *Enceladus*, having been detected on the evening of the day on which the great mirror received its final polish, on August 28, 1789; the other, *Mimas*, the nearest satellite to *Saturn*, was discovered on the 17th of the following month.

If we were to analyse Sir William Herschel's contributions to astronomy contained in the *Philosophical Transactions*, we should find that no branch of what we may aptly term equatorial astronomy, in contradistinction to meridional astronomy, was left untouched by him. We can in imagination look back upon him at one time occupied on one of his favourite subjects of observation, the examination of double stars and nebulæ; at other times he might have been noticed recording the physical appearances and phe-

nomena of the different planets, or the apparent times of their rotation round their axes; the positions of his new planet *Uranus* and of various comets; the relative brightness of the stars; the variation in the magnitudes of the satellites of *Jupiter*, from which he determined the time of their rotation; the observation of newly-discovered satellites; experiments on the refrangibility of the invisible rays of the Sun; or on a great number of other equally important observations; and on the construction of his telescopes. But most of these subjects refer to his telescopic work; so that if we follow him into his study, we shall see him employed on some most interesting investigations of the highest scientific value, especially on those relating to his speculations on the probable constitution of the stellar universe, and the distribution of the stars in space; or on that masterly discussion of the proper motions of stars, which enabled him to point out the approximate direction and motion of the solar system, which has been the key-note of all the subsequent investigations on that subject.

During Dr. Herschel's frequent examinations of *Uranus* with his forty-feet reflector, he recorded the positions of several minute objects near the planet, which he concluded belonged to its system. Six satellites were therefore for many years supposed to be attendant on *Uranus*, till the planet in later years was scrutinised very closely, principally by Mr. Lassell, F.R.S., first in 1847 at his observatory near Liverpool, and afterwards in 1864 and 1865 at Malta, where he had transported his twenty-feet reflector. From Mr. Lassell's observations, as well as from those of Otto

Struve, and other astronomers, there appears now to be no doubt about two satellites, *Ariel* and *Umbriel*, whose positions with respect to *Uranus* have been satisfactorily determined within the nearest of Sir William Herschel's six, and that only two, *Oberon* and *Titania*, out of the original satellites can now be identified. From analogy, *Uranus* should have more than four moons; but so far as the most powerful of our modern telescopes have revealed to us, we can only safely credit it with Sir William Herschel's second and fourth, and the two discovered in 1847, *Umbriel* by M. Otto Struve, and *Ariel* by Mr. Lassell. Probably the objects seen by Dr. Herschel and not since identified were very minute stars which happened to be near the planet on the nights of observation.

We have already mentioned that William Herschel brought his sister, Caroline Lucretia, from Hanover in 1772, as his companion and housekeeper. This lady, like all her brothers and sisters, was an accomplished musician, and was accustomed, while resident at Bath, to be first singer at the concerts whenever her brother was conductor. But it is entirely as his amanuensis and assistant that the scientific reputation of Miss Herschel was made. Whenever the brother was occupied in his sweepings, and this was on every clear night, the devoted sister was always ready at hand to record the observations, or to read a micrometer-head, or to prepare some refreshment necessary during a long night's watching. She was willing to sacrifice all personal comfort, if she could in any way relieve her 'dear' brother (as she frequently wrote of him) of any of the drudgery

incidental to such continuous night-work. While the great astronomer was beholding in his far-famed telescope some new object never before observed, she was certain to be at hand and ready to record its position and features, inwardly rejoicing that fresh material was being stored to add to her brother's fame. Arduous, however, as these occupations were, especially when we consider that on favourable nights in winter the sweepings were often continued till day-break, they were not sufficient to prevent her following her daily employment. Through all her duties, she found time to make herself acquainted with sufficient mathematics to make her interested in her brother's pursuits, and in astronomical questions. As an assistant, she was most valuable; and it was her duty to enter all the results of the sweepings into the books, and to execute all the copying required in the preparation of the different catalogues of double stars and nebulæ for press. Miss Herschel was not, however, simply an attendant on her brother at nights, but she occasionally observed on her own account with considerable success. When Dr. Herschel was absent, or prevented by any cause from observing, she had the use of a Newtonian telescope, with which she searched the heavens for comets, of which eight were detected by her, five being actual discoveries of comets never before observed. She also found several remarkable new nebulæ and clusters of stars. For her reduction to January 1800 of the positions of all the nebulæ discovered by her brother, which she completed after his death, she was awarded, in 1828, the Gold Medal of the Astronomical Society of London,

in presenting which, Sir James South, F.R.S., thus spoke of her services:—'Who participated in the toils of William Herschel? Who braved with him the inclemency of the weather? Who shared his privations?—A female! Who was she?—His sister! Miss Herschel it was who by *night* acted as his amanuensis! She it was whose pen conveyed to paper his observations as they issued from his lips; she it was who noted the right ascensions and polar distances of the objects observed; she it was who, having passed the night near the instruments, took the rough manuscripts to her cottage at the dawn of day, and produced a fair copy of the night's work on the subsequent morning; she it was who planned the labour of each succeeding night; she it was who reduced every observation, and made every calculation; she it was who arranged everything in systematic order; and she it was who helped him to obtain an imperishable name."[1] In 1835, Miss Herschel was elected an Honorary Member of the Royal Astronomical Society. Two months after the death of her brother, she retired to Hanover, after a residence in England of fifty years. The latter part of her life was passed in the society of her remaining relatives and friends; her faculties continuing perfect and her memory remarkably clear and distinct, as is evidenced by her interesting letters down almost to the close of her life. She died tranquilly and free from suffering on January 9, 1848, being within a few months of completing the ninety-eighth year of her age.

Alexander Herschel, who assisted his brother so

[1] *Monthly Notices, R.A.S.*, vol. i. p. 63.

materially in his mechanical arrangements in connection with the construction of telescopes, continued to reside in Bath after his relatives removed to Slough. He was well known in Bath and Bristol during forty-seven years as principal violoncello, and an elegant performer and musician. He was, however, in the habit of occasionally visiting Slough, and taking part in the manipulations of the workshop. On account of failing health, he returned to Hanover in 1816, where he died on March 15, 1821, aged seventy-five.

Sir William was fortunate in having two such devoted assistants as his sister and brother proved to be, the former as his housekeeper till his marriage, and the latter in the workshop. On May 8, 1788, he married Mary, widow of Mr. John Pitt, and daughter of Mr. Baldwin, of Slough, a City merchant. She was a lady of considerable property, which with his pension from the Crown, and the profits arising from the sale of his mirrors, soon placed him in affluent circumstances.[1] The latter years of his life were passed in comparative ease and retirement at Slough, under the shadow of his great telescope, which had then almost done its work. He was much gratified at the success of his only son at Cambridge, and by the somewhat tardy honour of Hanoverian Knighthood conferred on him in 1816 by the Prince Regent. He was probably quite as much pleased with the scientific compliment offered to him by his friends

[1] Sir William Herschel must have found the construction of telescopes a very profitable commercial speculation. For a fine instrument ordered by the King of Spain in 1796, and completed in 1804, he received the large sum of 3,150*l.*, and two smaller telescopes were sold by him to the Prince of Canino for 2,310*l.*

and fellow-astronomers, when he was unanimously chosen as the first President of the newly founded Astronomical Society, which office he held at the time of his death. The health of Sir William gave signs of gradually breaking up some years before his final illness, but during the spring and summer of 1822 every one around him were prepared for a fatal termination at any moment. He was unable to leave his bed during the last ten days of his life, becoming daily weaker. 'For ten days and nights,' his sister Caroline writes in her Diary, 'we remained in the most heart-rending situation till the 25th of August, when not one comfort was left to me but that of retiring to the chamber of death, there to ruminate without interruption on my isolated situation. Of this last solace I was robbed on the 7th of September, when the dear remains were consigned to the grave.' Thus passed away one of England's greatest astronomers, having nearly completed his eighty-fourth year, leaving his widow, his already distinguished son, and his devoted sister Caroline, to mourn his death. Lady Herschel survived her husband more than nine years. She died at Windsor on January 6, 1832, aged eighty-one. Both Sir William and Lady Herschel were buried beneath the tower in the old parish church of St. Laurence, Upton.[1]

The following is the inscription on the monument of Sir William Herschel in the church of St.

[1] The parish of Upton-cum-Chalvey has three churches: the old mother-church of St. Laurence, Upton, where the Herschels are

Laurence, Upton,[1] supposed to have been written by the late Dr. Whewell, F.R.S., Master of Trinity College, Cambridge :—

H. S. E.

GULIELMUS HERSCHEL Eques Guelphicus
Hanoviæ Natus Angliam Elegit Patriam
Astronomis Ætatis Suæ Præstantissimis
Merito Annumeratus:
Nam ut Leviora Sileantur Inventa
Planetam Ille Extra Saturni Orbitam
Primus Detexit
Novis Artis Adjumentis Innixus
Quæ Ipse Excogitavit Et Perfecit
Cœlorum Perrupit Claustra
Et Remotiora Penetrans Et Explorans Spatia
Immensos Stellarum Duplicium Gyros
Astronomorum Oculis Et Intellectui Subjecit.
Quâ Solertiâ
Radios Solis Analysi Prismaticâ
In Calorem Ac Lumen Distinxerit
Quâ Sedulitate
Nebularum Et Phantasmatum
Extra Systematis Nostri Fines Lucentium
Naturam Et Situs Indagaverit
(Quicquid Paulo Audacius Conjecisset
Ingenitâ Temperans Verecundiâ)
Ultro Testantur Hodie Æquales :
Vera Esse Quæ Docuit Pleraque
Siquidem Futuris Ingeniis Subsidia
Debitura Est Astronomia
Agnoscent Forte Posteri
Vitam Utilem Innocuam Amabilem
Non Minus Felici Laborum Exitu

[1] Kindly copied, at the request of the author, by the Rev. P. W. Phipps, M.A., Vicar of Upton-cum-Chalvey.

Quam Virtutibus
Insignitatem Et Vere Eximiam
Morte Suis Et Bonis Omnibus Deflendâ
Nec Tamen Immaturâ Clausit
Die XXV. Augusti. A. S. MDCCCXXII
Suæ Vero LXXXIV.

PAUL A. E. LAUGIER.

1812–1872.

PAUL AUGUSTE ERNEST LAUGIER was born at Paris on December 22, 1812. He was the son of André Laugier, a distinguished chemist in the beginning of this century. He became a pupil in the École Polytechnique, from whence in 1834, in the second year of his studies, he was appointed to the Observatory at Paris as a pupil-astronomer, an office which had just been created at the instance of M. Arago. Under the direction of this distinguished astronomer, and assisted by the friendly counsel of his colleagues, MM. Bouvard and Mathieu, he soon became a skilful observer, and one of the most active assistants at the Observatory. Although generally employed in the harassing daily routine of the ordinary observing work, he found time and zeal to undertake, on his own account, a special series of observations of solar phenomena. In 1841 he presented to the Academy of Sciences a Paper *On the Movements of the Solar Spots*, a brief abstract of which appeared in the *Comptes Rendus* for 1843. In this memoir, Laugier gave as one of the results of his research, that the solar spots had a peculiar motion of their own, independently of that produced by the motion of the photosphere in the neighbourhood of the spot, and

that the time of rotation of the Sun on its axis, determined from the observation of several spots, is not, from this cause, always accordant. Although he was himself convinced of the certainty of the results of his solar investigations, Laugier at this time was one of those modest men who have too little confidence in their powers to venture laying their first speculative deductions before the criticising eyes of their fellow-workers; hence this memoir was never published in its entirety. It has been remarked by M. Faye, that 'others have followed in his track; a new branch of science has taken birth on the ground which he had broken, and which is being rapidly developed. It is not, however, the less true that we owe the first germs of it to the unfinished memoir of Laugier, and it is at this moment a melancholy satisfaction for me to have waited until now, before making it public.'

The onerous duties which necessarily fall upon a young and active observer at all hours in a large Observatory, are generally considered to form a sufficient excuse for devoting his leisure time to other and less scientific occupations. Laugier's love for astronomy, however, would not permit him to do this. He soon made himself acquainted with the method of calculating elements and ephemerides of comets. He was also the discoverer of a telescopic comet in the constellation *Draco* on October 28, 1842. In a few days after the discovery, he published the elements of its orbit. For this joint work, as discoverer and calculator, the Academy awarded him the Lalande Astronomical Prize in 1843. Besides devoting much atten-

tion to the observation of this comet, Laugier presented several important papers to the Academy, abstracts of which are inserted in the *Comptes Rendus.* Among these are the following:—*On the Orbit of Halley's Comet at its appearance in* 1835; *On the Comet discovered at Marseilles by M. Gambart*; and *On the ancient appearances of Halley's Comet, especially that observed by the Chinese Astronomers in* 1378.

On the death of M. Arago in 1853, some of the assistant-astronomers, including Laugier and his father-in-law, M. Mathieu, declined to submit to the control of the new Director, M. Le Verrier, who was desirous of making considerable changes in the daily routine-work of the Observatory, and in the relative positions of the assistants. Owing to M. Laugier's family connection with M. Arago, he was led to believe that personal difficulties would be certain to arise, were he to remain subordinate to one whose ideas of management were, in many respects, antagonistic to those of the former Director, and thus he very reluctantly retired from an office which was exactly suited to his tastes. He deeply regretted the loss of the use of the instruments at the Observatory, as several investigations on which he was engaged were still unfinished, and he might never have the opportunity of completing them. M. Laugier soon found, however, that he need have no fear on this point. At his residence in the Rue Notre Dame des Champs, he established a small private observatory, and here, in the society of his friends, Mathieu and Delaunay, he was enabled to continue the investigations which were interrupted by his secession from the Observatory.

The author visited him here in the years 1854 and 1855, when Laugier was busily occupied on these researches, one of which was his important memoir on the determination of the polar distances of the fundamental stars. A remark made by him at one of these visits may well be recorded as an excellent illustration of the great respect he and many other foreign astronomers have entertained for the long and continued series of fundamental observations of the planets and principal stars made at the Royal Observatory, Greenwich, since the days of Bradley. Alluding to the work at Greenwich, and pointing to some volumes of the *Greenwich Observations* on the shelves of his library, he exclaimed with considerable animation :—'No books in my library are so precious, in my estimation, as these annual records of the skill, order, and continuous labour of my *confrères* at Greenwich.' This remark was made with all sincerity, and certainly not as a compliment to the author, who was, in these years, sent to Paris, by the Astronomer Royal, on important scientific Missions.

The memoir on the north polar distance of fundamental stars was published, in 1857, in vol. xxvii. of the *Mémoires de l'Académie des Sciences.* The observations were made with the mural circle o Gambey at the Paris Observatory, commencing at the end of 1851 and continued till M. Laugier finally left the Observatory. At this time, the observations of the selected stars were nearly completed. M. Laugier has divided the introduction to the tabular matter into two sections. In the first, he gives a description of the mural circle of Gambey, and a detailed exposi-

tion of the processes employed in the reduction of the observations; while in the second he discusses the north polar distances of 140 stars given in the principal published star-catalogues, the separate values in which he has combined to form one normal catalogue. With these standard places he has compared the separate north polar distances contained in each, and also those resulting from his own independent determination. The comparison shows that the mean probable error of M. Laugier's north polar distances for all the stars is only $\pm 0''.447$, a proof of the general excellence of his observations. Continuing his investigations on a similar subject, he communicated, in 1858, a very interesting paper to the Academy of Sciences, in which he points out that the observations of *Sirius*, in north polar distance, indicate a variability of proper motion similar to that which had been previously established by the researches of Bessel and C. A. F. Peters on the right ascensions of this star. The data used by Laugier were collected by him from the most trustworthy observations of *Sirius* made between the years 1690 and 1852, classed into groups representing fourteen epochs of north polar distance.

In the *Comptes Rendus* for 1853 are papers by M. Laugier on a new and very accurate determination of the latitude of the Observatory of Paris from the meridional observations of circumpolar stars, and a catalogue of nebulæ observed during the years 1848 and 1849. On many occasions, Laugier afforded considerable assistance to Arago in his physical researches, including those on photometry and magnetism. In 1847, he investigated the proper motion of three stellar

clusters formerly observed by Messier. He was also the author of an excellent treatise on a portable meridian-circle, devised principally for the use of naval officers for the determination of geographical positions on shore. This work was published under the authority of the Dépôt Général de la Marine.

In June 1843, M. Laugier was appointed an assistant-member of the Bureau des Longitudes, in the room of Savary, and he became a titular member in 1862. After the death of Arago, the preparation of the *Connaissance des Temps* and the *Annuaire* became almost the only official duty left to the care of MM. Mathieu, Laugier, and other active members of the Bureau des Longitudes, who were responsible for the annual publication of these works. Since 1861, Laugier undertook a very important part of the calculations of the *Connaissance des Temps*, especially of those portions which could not well be entrusted to ordinary computers, such as the section containing eclipses of the Sun and Moon, the tides, and occultations of stars by the Moon. Through his suggestion, also, the eclipse-maps, similar to those found to be so useful in the *Nautical Almanac*, were inserted. He was in the habit of making for many years a series of observations of the magnetic inclination and declination for publication in the *Annuaire*.

M. Laugier was elected in 1843 a Member of the section of Astronomy in the French Academy of Sciences, and an Associate of the Royal Astronomical Society in 1848. For some years preceding his death, he held the office of Examiner at the Naval School at Brest, where he was ever anxious to encourage a

taste for scientific pursuits. He always felt an infinite pleasure in recommending the young marine officers to the notice of the Bureau des Longitudes, whenever they showed any skill in nautical science.

M. Laugier married the daughter of M. Mathieu and the niece of M. Arago. For some years his health had not been satisfactory,—ever since, in fact, the death of his son, a youth of great promise. The premature loss of his brother in February 1872—a man also distinguished in science, and only a few months before chosen a Member of the Academy of Sciences in the section of Medicine—for whom, on account of their difference of age, he had almost a parental tenderness, had a great effect upon his spirits, and the combined stroke evidently tended to shorten his days. His death took place at Paris on April 5, 1872, in the sixtieth year of his age. He succumbed, at last, to a severe attack of gout of several days' duration. His loss was deeply deplored in the scientific salons of Paris, which were thus deprived of the society of one whose whole life was a model of integrity. His manner was calm and reserved, apparently approaching to coldness; but those who knew him best have spoken of his goodness of heart, and of the honesty of purpose which guided him in all the relations of life. No more appropriate conclusion to this brief sketch can be given than that contained in the following remarks made at his grave by the lamented Delaunay, who, alas! was so soon to follow him :—'Laugier was truly a friend of mine. For the last eighteen years we have lived in the greatest intimacy. Living under the same roof, occupying ourselves on similar researches, we

were always in each other's society. Our lives were bound up together; we were as one individual. It is from this daily intercourse with him that I have been able to appreciate all that was good and honest in his heart; all that was right-minded in his judgment. I naturally sought his counsel under all circumstances. Never have I found his advice at fault; never have I had cause to regret following it. Laugier will no longer exist among us, but he will never cease to live among my most cherished remembrances.'

URBAIN J. J. LE VERRIER.[1]

1811–1877.

WHEN it was publicly announced in the spring of 1877 that the great French astronomer and Director of the Paris Observatory was laid aside by illness, few anticipated that his end was so near, and that astronomy was so soon to be deprived of the services of one of the most gifted of its adherents. The loss of so eminent a mathematician and astronomer, at the height of his reputation, cannot fail to be deplored by every scientific man throughout the civilised world, especially by those who can appreciate the importance of the herculean task which he successfully accomplished in some of the highest branches of gravitational astronomy. Probably no one but Le Verrier himself knew the amount of labour bestowed on his life-long investigations of the theories of the movements of the primary planets in their orbits; but that it was something enormous may be conceived from the expressions of a friend and fellow-worker, than whom no one is more qualified to give an opinion. Professor Adams, F.R.S., while addressing the Fellows of the Royal Astronomical Society, on the occasion

[1] Frequently written as one word, Leverrier. We prefer to follow the orthography adopted by Le Verrier himself, both in his printed works and private letters.

of the presentation of the Gold Medal to M. Le Verrier in 1876, spoke as follows :—'That any one man should have had the power and perseverance required thus to traverse the entire solar system with a firm step, and to determine with the utmost accuracy the mutual disturbances of all the primary planets which appear to have any sensible influence on each other's motions, might well have appeared incredible if we had not seen it actually accomplished.'[1]

The physical strength required to perform all this incessant labour would have severely taxed the most iron constitution ; but of late years M. Le Verrier's health was far from being satisfactory, and fears were often expressed that it would probably give way before he had time to complete his work. It was therefore a great consolation to him in his last illness to know that his life was prolonged sufficiently for him to finish his planetary investigations, and to superintend the formation, from his revised theories, of a series of tables for each of the major planets, from *Mercury* to *Neptune*. Most of the formulæ relating to these planetary researches are published in the stately volumes of the *Annales de l'Observatoire de Paris*, where they will remain an enduring monument of the gigantic intellect and steady perseverance, often under difficulties, of this great mathematician, whose name will descend to posterity as that of one of the most illustrious of the scientific worthies of the nineteenth century.

In this brief and necessarily imperfect sketch of the scientific career of M. Le Verrier, it will be im-

[1] *Monthly Notices, R.A.S.*, vol. xxxvi. p. 235.

possible to give more than the barest outline of, or even to refer to, more than a few of his principal contributions to astronomy. His greatest work has been so faithfully reviewed in the excellent addresses delivered at the anniversary meetings of the Royal Astronomical Society in 1868 and 1876, by two of its most valued Presidents, that the reader can hardly do better than refer to these addresses for a complete *résumé* of all Le Verrier's planetary researches; the first by Professor Pritchard, F.R.S., of Oxford, being an elaborate essay on the tables constructed from his theories of *Mercury*, *Venus*, the Earth, and *Mars*, which have superseded all other tables for the calculation of the tabular places of these planets in their respective orbits, as given from year to year in the *Nautical Almanac*. The second address, by Professor Adams, F.R.S., of Cambridge, refers more particularly to the theories of the four great planets, *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, and on the tables of *Jupiter* and *Saturn*, founded on their respective theories. Since this address was delivered, the tables of *Uranus* and *Neptune* have also been completed.

URBAIN JEAN JOSEPH LE VERRIER was born on March 11, 1811, at St. Lô, in the department of Manche. Of his early life, before his entry into the École Polytechnique at Paris, we have been unable to find any record. He had reached his twentieth year before he became a pupil in that well-known nursery of French scientific men, where he remained for the usual period. He left the school in 1833 with a high reputation as a mathematician. At that time his principal object was to obtain employment in the

Civil Service of the Government, and his position in the school gave him the privilege of choosing the department most congenial to his inclination. By his own choice, therefore, he was appointed to the office of a civil engineer in the 'Administration des Tabacs.' Here part of his duties involved employment in the laboratory; and he thus obtained a practical knowledge of chemical manipulation, which led him on to original investigation, the results forming the subjects of his first two published scientific papers. After remaining some years in the position of engineer to this establishment, Le Verrier was appointed to a tutorship in the Stanislaus College at Paris, and also in the École Polytechnique. In 1846 he was appointed Professor of Astronomy in the Faculty of Sciences, a year memorable to him as that in which the remarkable discovery of *Neptune* took place. From this time he never ceased taking an active part in the promotion of higher education in France, and his scientific lectures at the Sorbonne, &c., were much sought after by the students. In this manner he remained professionally employed as a teacher and lecturer on mathematics and astronomy, till the beginning of 1854, when he received from the Emperor Napoleon the important appointment of Director of the Imperial Observatory of Paris, which had become vacant by the death of M. Arago in October 1853.

As soon as Le Verrier finished his education at the École Polytechnique, his inclination for scientific research soon brought his name forward as that of one of the most promising of its students, though, as

we have before remarked, the special subject of his early inquiries was not that in which he afterwards so greatly distinguished himself. While serving as an engineer in the office of the 'Administration des Tabacs,' it might almost have been predicted that his original talents would have been devoted to chemical pursuits rather than to astronomical research, judging from the first offshoots of his inquiring mind. His two papers in the *Annales de Chimie*, one published in 1835 on the combination of phosphorus and hydrogen, and the second in 1837 on the combination of phosphorus and oxygen, certainly gave evidence that work in the laboratory was at that time a congenial occupation. But many years before the publication of these papers, Le Verrier had his thoughts directed to the great astronomical problems which afterwards occupied so large a portion of his busy life; for so early as 1832, before he had concluded his studies at the École Polytechnique, his attention had been directed to the large outstanding errors in the planetary theories, and the chief English mathematicians were no strangers to this early development of his great analytical powers. A distinguished, though anonymous, writer in the *Daily News*, when announcing to the public the great loss to science caused by the death of the illustrious astronomer, stated that, 'so early as 1832, M. Le Verrier was first known to the mathematicians of this country by his scrupulous examination of the investigation by the present Astronomer Royal of a long inequality in the motions of the Earth and *Venus*. This examination, however, communicated by M. Poisson to Sir John Herschel, was known to

few except the parties immediately concerned.'[1] When his first contributions to his researches on the planetary theories were circulated in England, his intellectual power was therefore at once recognised as being fully equal to the colossal undertaking he had commenced, and which he evidently resolved to complete if his health permitted.

The first published astronomical memoir of Le Verrier appears to be the important investigation inserted in abstract in the *Comptes Rendus* for 1839, vol. ix., and *in extenso* in the additions to the *Connaissance des Temps* for 1843, but published in 1840, on the secular variations of the elements of the orbits of the planets *Mercury*, *Venus*, the Earth, *Mars*, *Jupiter*, *Saturn*, and *Uranus*. This investigation proved to be the beginning of his unique planetary researches, which as a whole appear so colossal to the imagination, that of those who were able to form a correct idea of the amount of close application required for such a work, probably there were very few, if any, who could in 1840 look forward to its completion in the limited span of a single life. In this remarkable memoir, in which the subject is treated with consummate power, Le Verrier has given the amount of the secular changes in a tabular form, exhibiting the variation of the elements of the orbits of *Mercury*, *Venus*, the Earth, and *Mars* for intervals of 20,000 years, from 100,000 years before to 100,000 years after the epoch 1800. Probably at this time Le Verrier hardly expected to include in his investigations the theories of *all* the major planets, what-

[1] *Daily News*, September 24, 1877.

ever his wishes might have been, or whatever energy he might have been able to throw into his work, when he felt himself committed to the task. He, however, went silently onwards year after year, notwithstanding many private and public difficulties, which frequently interrupted him in his labours. These hindrances, which in other hands might have proved fatal, were much increased after his appointment to the directorate of the Paris Observatory, owing, in the first place, to the necessity of a perfect reorganisation of the establishment, which absorbed much of Le Verrier's time for a considerable period, and to the want of harmony in his relations with his subordinates; and, secondly, to his temporary removal from his office in March 1870, and to the changing political events in that and following years. Le Verrier's health suffered much from anxiety during the investment of Paris by the German army; and, while Paris was in the power of the insurgent Commune, great fears were entertained for his personal safety. He, however, fortunately escaped; but these sad events interrupted his labours more than his foreign friends ever knew, and, through his uncertain health, it appeared extremely doubtful at this time whether he would ever again be in a position to renew his astronomical investigations. With the return of order in Paris, his anxieties were sensibly diminished; but it was not till his restoration to the Observatory, after the melancholy death of M. Delaunay, that he was in a condition to resume his planetary work with his usual vigour. He never, however, recovered his former good health; but, happily, it was sufficiently preserved

to enable him to complete the task undertaken in 1839, when he laid its foundation in his memoir relating to the secular variations of the elements of the orbits of the major planets.

M. Le Verrier's first astronomical memoir was speedily followed by two others in the same year,—one on the motion of the inclination of the nodes in the orbits of the three planets, *Jupiter*, *Saturn*, and *Uranus*, and the other on the calculation of the secular inequalities given by M. de Pontécoulant in the third volume of his *Système analytique du Monde*. These papers are also inserted in the *Comptes Rendus*, vol. ix. From this date, the *Connaissance des Temps*, the *Comptes Rendus*, the *Annales de l'Observatoire de Paris*, and other scientific publications, are rich with Le Verrier's mathematical and astronomical contributions.

On November 11, 1844, Le Verrier presented to the Academy of Sciences[1] his first memoir on the theory of the periodical comet of 1770, discovered by Messier in June of that year, in the constellation *Sagittarius*, known generally at the present time as *Lexell's Comet*. After passing its perihelion this comet reappeared in the first week in August, and remained visible till early in October, when it finally disappeared. When it was found that the motion of a telescopic comet, discovered in 1843 by M. Faye, of the Observatory at Paris, deviated considerably from the path as described by a parabolic orbit, and that it indicated that the true form of the orbit was an ellipse, with a period of about seven and a half years, some astronomers conjectured that the newly-

[1] *Comptes Rendus*, vol. xix.

discovered object might possibly be identified with the lost comet of 1770. In 1776 Lexell pointed out that the original observations could be explained on the hypothesis that the orbit was elliptical, and that the comet was affected in 1767 by the attraction of the planet *Jupiter*, and would be again in 1779 by the renewed perturbations of that powerful planet. On this assumption Lexell inferred that the form of the orbit would become so much changed, that the comet would probably depart for ever from the solar system, and he therefore anticipated what appears to have taken place. The observations of this remarkable comet have also been discussed by Burckhardt and Laplace, the results of which are inserted in the *Mécanique Céleste.*

Though the subject appeared to be exhausted by the analytical researches of Laplace, which were received with confidence by astronomers, Le Verrier resolved to make an independent and thorough examination of the question in relation to some recently-discovered comets of short period, which he considered might possibly be identified with Lexell's comet. He therefore traced back the unseen motions of not only the comet of Faye, but also that of De Vico, discovered in 1844, and of Brorsen, discovered in 1846, for three quarters of a century, so as to ascertain their positions at the epoch of 1779, but with the result that neither of the three comets could be identified with the comet of 1770. The full details of this laborious investigation are given in the third volume of the *Annales de l'Observatoire de Paris.* Le Verrier's general conclusions are:—1. That if the comet had

passed within the Jovian system, the attraction of *Jupiter* would be powerful enough to cause it to fall down upon its surface, and thus coalesce with the planet, which, however, he considers to be highly improbable, though not absolutely impossible. 2. The perturbations produced by *Jupiter* may have changed the form of the comet's orbit from an ellipse to a parabola or hyperbola, in which case it must have departed from our system altogether, unless some disturbance produced in another sphere of attraction caused the comet to move in an elliptic orbit as before. 3. Or the orbit may have become elliptical, having a great axis and long period, and of such a form that the comet could never become visible—a supposition in accordance in some degree with the solution of Laplace, who, in his *Mécanique Céleste*, has considered it possible that the comet may have been brought within our system, but, at a later approach, the form of its orbit may have undergone so much change during the interval as to render it invisible. 4. But, what is equally possible, the elliptic elements may have been more or less modified by the action of *Jupiter*, and still the orbit might retain its character of short periodicity. M. Le Verrier considered that this assumption was perhaps the most probable, and that the missing comet of 1770 may even yet be identified with some undiscovered comet of short period. These investigations of Le Verrier occupied his attention at different times, and were presented to the Academy of Sciences first in 1844, and again in 1848. The complete numerical details were, however, not published till 1857.

The early astronomical papers of Le Verrier soon fell under the notice of M. Arago, the Director of the Paris Observatory, at whose suggestion he undertook the calculations of the perturbations of *Mercury* in relation to the attraction of other planets. It was also at the urgent request of Arago, and known to other mathematicians in Paris long before the sensational discovery of *Neptune*, that Le Verrier had commenced a new investigation of the theory of the motion of *Uranus*, whose apparent irregularities in its orbit were so well known. That these observed discordances from theory were produced by the perturbations of an exterior planet was a notion entertained in the minds of many mathematical astronomers, several years before Le Verrier or Adams undertook to re-examine the theory of *Uranus*, there is more than one record. In a letter to the Astronomer Royal, dated October 6, 1837, M. Eugène Bouvard, nephew of the author of the tables of *Uranus*, writes: —'En consultant les comparaisons que vous avez faites des observations de cette planète (*Uranus*) avec les calculs des tables, on voit que les différences en latitude sont très-grandes et qu'elles vont toujours en augmentant. Cela tient-il à une perturbation inconnue apportée dans les mouvements de cet astre par un corps situé au-delà? Je ne sais, mais c'est du moins l'idée de mon oncle. Je regarde la solution de cette question comme fort importante.' The Astronomer Royal remarked, in reply, that it was in the longitude that the greatest errors were exhibited, and that they were increasing with fearful rapidity. The progressive increase in the errors of the tables are

shown in the yearly volumes of the *Greenwich Observations*, where the observed places of the planet are compared with the places calculated from the tables of Bouvard, as given in the *Nautical Almanac*.[1]

Le Verrier communicated his first memoir relating to the theory of *Uranus* to the Academy of Sciences in 1845, and it appeared in the *Comptes Rendus* for November 10 of that year. It consists of an investigation of the perturbations of *Uranus* produced by *Jupiter* and *Saturn*, and on the errors in the elliptic elements of *Uranus* consequent on the use of erroneous perturbations in the treatment of the observations. Sir George Airy, F.R.S., commenting at the time on this important work, remarked that 'perhaps it may be truly said that the theory of *Uranus* was now, for the first time, placed on a satisfactory foundation.' A second memoir on the theory was presented to the Academy a few months afterwards.

The first part of the second memoir contains a fresh reduction of all the available observations of *Uranus*, treated with reference to the theory of perturbations given in the former memoir. Le Verrier saw sufficient evidence in the observed discordances to convince him that they could not be reconciled with the theory, unless we admit the existence of a disturbing planet exterior to *Uranus*. He then undertook to investigate the elements of such a body,

[1] From January 1, 1877, to December 31, 1881, the places of *Uranus* in the *Nautical Almanac* are derived from Newcomb's tables. From January 1, 1882, the more recent tables of Le Verrier have been used.

and finally he gave 325° as its true longitude at the beginning of 1847, with a probable error of ten degrees. In a third and concluding paper, presented to the Academy on August 31, 1846, Le Verrier gave a series of approximate elements of the disturbing planet, differing to no great extent, considering the difficulties of the problem, from those independently determined by Mr. J. C. Adams, of St. John's College, Cambridge, and forwarded by him to the Astronomer Royal some time before the publication of Le Verrier's elements. These two independent researches have proved to be the subject of one of the most remarkable coincidences in the history of astronomy; for here we have two mathematicians of the highest rank, personally unknown to each other, devoting their trained intellects to the consideration of one of the most intricate problems of mathematical astronomy, and this so successfully, that each announced to the world the approximate position of an unknown planet within a few weeks of each other. The names of these two gifted astronomers should therefore always be linked together as the investigators to whose joint labours we owe the detection of the planet *Neptune*, though its actual discovery was undoubtedly due, in the first place, to the French astronomer.[1] The disputed question of the priority of the

[1] Before Le Verrier's elements of the orbit of the suspected planet were known in England, a systematic search was made for it by Professor Challis, F.R.S., at the Cambridge Observatory. The search was begun on July 29, and continued till the announcement of the discovery of *Neptune* at Berlin. On a subsequent examination of the relative positions of the stars recorded by Professor Challis, it was found that the planet had been actually observed on August 4. Had

investigations of Le Verrier and Adams formed the subject of a sharp controversy immediately after the discovery of *Neptune*; but at the present time there is every disposition, on the part of both English and foreign astronomers, to give due credit to each for their individual labours which led to the detection of the suspected planet exterior to *Uranus*.

Probably every reader of the history of our science knows that the predicted place of the suspected planet, deduced from the hypothetical elements of M. Le Verrier, was transmitted by him to Dr. Galle, of the Observatory of Berlin, who was invited to search for the planet in the neighbourhood of this assumed place, and that it would probably be easily recognised by its disk. Le Verrier's request was received at Berlin on September 23, and fortunately the weather proved to be favourable on the same evening for the observation of faint objects. Taking one of Dr. Bremiker's Berlin star-maps, Hora XXI., as his guide, Dr. Galle in a short time detected a star of the eighth magnitude which was absent from the map. His plan of comparison was to record anew on a rough chart the relative positions of all the stars near the supposed place of the planet, and then to compare the position of each star in this chart with its corresponding position relatively with those near it on the engraved map. By this means a new star not in the Berlin map was detected and became a suspicious object. Subsequent examinations made on the same

the examination been made daily, instead of being deferred, this object would have certainly been identified as the planet at least seven weeks before its detection by Dr. Galle.

evening gave slight indications of motion in the star; but this was clearly proved on the two following evenings, when decided changes of position with respect to the other stars was perceived, and the motion showed that it was in the direction of, and nearly equal to, that predicted by Le Verrier. Hence the new planet *Neptune* became recognised as the most distant known member of the solar system. This remarkable discovery created the most intense excitement in all Observatories, and sufficient observations were soon made to enable correct elements of its orbit to be calculated. The first meridional observations of *Neptune* at the Royal Observatory, Greenwich, were made on October 3, 1846, with the transit-instrument and the mural-circle, and a fine series was obtained before the end of the season. The planet was also observed at Greenwich with the Sheepshanks equatoreal, on the same and following days.

When accurate elements of the orbit of *Neptune* were calculated from the observations, it was found that they differed sensibly from those hypothetically determined by Le Verrier and Adams, especially in the periodic time, which turned out to be very much smaller than that predicted. It is, however, no reflection on the fame of either of the two mathematicians that this was the case; for more could scarcely be expected than that they should agree near enough to enable an observer to identify the planet from the neighbouring stars in a few hours, and so well as to point to the exact celestial locality where it might possibly be found. The actual discovery was no doubt hastened by the energy exhi-

bited by Le Verrier in communicating, without delay, the theoretical place of the planet to an active observer and practical astronomer, as soon as he had satisfied himself of the truth of his hypothesis, in which he evidently felt perfect confidence. Dr. Galle was asked to look in one particular spot in the heavens with the best telescope at his command, and there to his amazement the planet *Neptune* was shining before his eye. We cannot confer greater honour on the memory of the illustrious French astronomer, in connection with this intellectual triumph, than by quoting the words of the Astronomer Royal, with reference to Le Verrier's third memoir, delivered at the ordinary meeting of the Royal Astronomical Society on November 13, 1846. 'I cannot attempt to convey to you the impression which was made on me by the author's undoubting confidence in the general truth of his theory, by the calmness and clearness with which he limited the field of observation, and by the firmness with which he proclaimed to observing astronomers, "Look in the place I have indicated and you will see the planet well!" It is here, if I mistake not, that we see a character far superior to that of the able, or enterprising, or industrious mathematician; it is here that we see the philosopher. The mathematical investigations will doubtless be published in detail, and they will, as mathematical studies, be highly instructive; but no details published after the planet's discovery can ever have for me the charm which I have found in this abstract which preceded the discovery.'[1]

[1] *Monthly Notices, R.A.S.*, vol. vii. p. 142.

Le Verrier's discussion of the relative right ascensions of thirty-six fundamental stars, deduced from the observations made at the Royal Observatory, Greenwich, was indirectly connected with his planetary researches, and it required a very laborious comparison of the observations of these stars made over a long series of years. These thirty-six selected stars had been constantly observed by Dr. Bradley and his successors at Greenwich, and nearly all of them are now incorporated in the list of stars whose mean and apparent places are given yearly in the *Nautical Almanac*. Bradley's thirty-six stars were, however, in the days of Maskelyne and Pond, generally referred to as 'Greenwich Stars.' Le Verrier communicated the first part of this memoir to the Academy of Sciences in the early part of 1852, and the second and concluding portion in December of the same year. It contains an exhaustive comparison of the right ascensions deduced from the observations made by Bradley between 1750 and 1762, with the modern observations extending from 1836 to 1850, observed under the superintendence of the present Astronomer Royal. Corrections to the tabular right ascensions in the *Tabulæ Regiomontanæ* are given for each star for every ten years from 1750 to 1850. Some interesting results confirming the variability of the proper motion of *Sirius*, first noted by Bessel, are given in this memoir, which is printed in detail in the *Annales de l'Observatoire*, vol. ii.

But by far the greatest of M. Le Verrier's astronomical investigations is his continued series of planetary researches, commencing with his memoir on the theory

of the motion of *Mercury*, presented to the Academy of Sciences in 1843; or more properly with his first contribution to the fundamental theories of the planetary system, published four years previously, on September 16, 1839. The numerous developments of the theory, added from year to year, are mentioned in successive volumes of the *Comptes Rendus*, some merely by their title only. Five memoirs on the general developments of the theory were presented and published in 1840, 1843, 1849, and 1855, while the formulæ relating to the secular inequalities have been specially treated in the memoirs of 1840 and 1841. The dates of the presentation to the Academy of the theory of the movements of each planet are:—*Mercury*, the first memoir in 1843, the second, containing the theory completely revised, in 1859; *Venus* in 1861; the Sun (the Earth) in 1853 and 1858; *Mars* in 1861; *Jupiter* in 1872 and 1873; *Saturn* in 1872 and 1873; *Uranus*, first presented in 1846, leading to the discovery of *Neptune*; but a new and complete re-investigation was laid before the Academy in November 1874, followed by the theory of *Neptune* a few weeks later. All these planetary theories represent the observations very closely; and it is a most remarkable fact, to which we have before alluded, that tables have been formed by Le Verrier for *all* these planets. Thus, by the labours of one man, the tabular positions of every major planet can be accurately calculated, based on the same methods of investigation, for any stated time before or after the present epoch. The tabular places in the *Nautical Almanac*, derived from Le Verrier's tables, have now been compared directly

with recent observations, so far as regards the Sun and the major planets from *Mercury* to *Jupiter*. A glance at the columns in the recent volumes of the *Greenwich Observations*, where the observed right ascensions and north polar distances of the Sun and planets are compared with the corresponding tabular right ascensions and north polar distances taken from the *Nautical Almanac*, exhibits the extent of the gain to astronomy and navigation resulting from the adoption of the new tables in the calculations of our national ephemeris.

The mathematical details of Le Verrier's planetary investigations are given in the *Annales de l'Observatoire*, and also the numerical tables based upon them. It was a very great gratification to him and his friends that his health was preserved to finish so immense an undertaking; and it is remarkable that the last volume of the *Annales*, prepared under his direction, contains the tables of the last planet in the system—the conclusion of his work of thirty-eight years of continuous labour. These fourteen volumes of the *Annales* will indeed be a lasting monument of the fame of the great French astronomer.

During the time that M. Le Verrier was engaged on his investigation of the theory of *Mercury* in 1843, he felt a considerable difficulty in explaining the cause of an apparent anomaly which he found in the results, and which he was unable to unravel till he had completed his second investigation of the theory of the same planet in 1859. He then came to the conclusion that, to bring everything into order, all that was required was to increase the motion of the peri-

helion by thirty-one seconds. To account for the cause of this hitherto unexplained motion of the perihelion, Le Verrier considered that it was probably owing to the presence, between *Mercury* and the Sun, of one or more small planets, or of matter in the form of minute asteroids, or even of cosmic dust. It was in consequence of this belief in the existence of sufficient cosmical matter pervading the space interior to *Mercury* to affect the motion of the planet, that he was led to take a great personal interest in any supposed transit of an intra-Mercurial planet across the face of the Sun, especially in that said to have been observed at Orgères, in the department of Eure-et-Loire, France, by M. Lescarbault, on March 26, 1859. In the *Comptes Rendus*,[1] Le Verrier gives a circumstantial statement of Lescarbault's observation and explanation of his rough record of the time of transit, which, though in many respects unsatisfactory, was sufficiently clear to convince him that the object seen was not an ordinary sun-spot, but that an intra-Mercurial planet had been observed. Le Verrier entertained this opinion all his life, and he has since attempted to identify this object with certain disk-like spots of which the appearance of several has been recorded. He was thus induced to make a careful examination of the observations of all these observed spots having a planetary form, assuming that they might reasonably be considered as representing one planet, so far as regards the time of conjunction with the Sun; the result of his research being that his convictions were strengthened that such a body really

[1] Vol. xlix. p. 379.

exists. He fully believed that if a systematic watch were kept on the solar disk for objects of this kind, this still hypothetical planet will eventually be discovered. In March 1877, a most favourable opportunity occurred for a possible transit of such an object, and M. Le Verrier issued a circular inviting astronomers to make a continuous search, at short intervals of time, during the three days on which the conjunction might possibly take place. His wishes were carried out most warmly by astronomers in both hemispheres, but nothing in the form of a planetary disk was seen.[1]

When, in 1854, M. Le Verrier succeeded Arago as Director of the Paris Observatory, his reputation rested solely on his great success as a mathematical astronomer, and he had little or no practical experience in the use of astronomical instruments, or in the administration of an establishment like that over which he found himself suddenly placed. For this reason, there were some of his scientific colleagues who were predisposed to predict that his management of so important an Observatory would prove a failure. But the same energy of character which carried him on in his theoretical researches was soon exhibited in the administrative duties which devolved upon him in his new position. It has been observed by many accustomed to the work of an observatory, that under his direction the ordinary observations were conducted with a vigour never before known in the Paris Ob-

[1] It is remarkable that during the time of totality in the solar eclipse of July 29, 1878, visible in the Western States of North America, at least two objects were noticed by Professor Watson and Mr. Swift near the Sun, in positions which seem to indicate that they may be intra-Mercurial planets.

servatory; though it must be allowed that this was not performed without interfering with the usual habits of the assistant-astronomers. M. Le Verrier was extremely anxious from the first to regulate the ordinary routine duties of the assistants in a manner similar to that so successfully carried out for so many years at Greenwich by the present Astronomer Royal. Principally for the benefit of the new Director at Paris, the general regulations of the Royal Observatory were published, near the end of 1853, by order of the Admiralty. While resident at the Paris Observatory in 1854, the author observed on several occasions how desirous Le Verrier appeared to be to inaugurate a system of observing acceptable to his assistants, and yet regular and invariable in its performance. His great aim was to follow, as far as practicable, the Greenwich regulations, even in matters of detail. At that time, he had only been in residence at the Observatory a few months; but he had already adopted a form of weekly arrangement of the observers, prepared after the model of that in use at the Royal Observatory, in which the names of the assistants charged with the observations to be made with the different instruments are inserted for each day during the week. No one more than Le Verrier knew what standard meridional work had been achieved under the Greenwich system, and he always acknowledged his indebtedness to it as the principal source from which he gathered the material that served him so well in his planetary researches. From the day he entered on his official duties his great desire was, as he has himself expressed it, to follow

a system that had produced such a long series of planetary observations and reductions, published in a state ready for the mathematician. How he succeeded is best understood by a reference to the Paris observations in the *Annales* (section of Observations), not only of his own, but of those of his predecessor also. In these volumes of tabular details there is abundant evidence of able direction and orderly management, due for the most part to Le Verrier's own personal superintendence of the most important reductions.

On the unfortunate misunderstandings which existed between Le Verrier and some of his assistants, frequently interfering with the regular work of the Observatory, and at last ending in open rebellion and to his removal from the Directorate, we have no desire here to make more than a passing remark. Acknowledging truly that he was peculiarly hasty in his temper, and that he was occasionally far too despotic in his manner to those under his official control,[1] still there can be little doubt that there were many faults on both sides. Every one acquainted with his character must have known that he had the welfare of astronomy at heart, and that he was very desirous to place his Observatory in the same rank as other national centres of practical astronomy. He knew that he would never accomplish this unless he were faithfully seconded by his colleagues, on whose zeal

[1] In 1854 the author was the unwilling witness of a painful scene, when an old assistant, who had been many years employed at the Observatory under Arago, was peremptorily discharged for a very trivial breach of duty.

and co-operation success must principally depend. This unity of spirit between the Director and his subordinates, however, rarely existed at the Paris Observatory. But notwithstanding all Le Verrier's failings and his difficulties of superintendence, he succeeded in raising the Observatory to a position second to none, as is evident to all who have access to the noble series of volumes of the *Annales.*

The *Annales de l'Observatoire de Paris* are divided into two separate classes of work—one containing the details of original investigations, and the other the reduced records of the observations made with the different instruments. Fourteen volumes of the section devoted to research appeared before the death of M. Le Verrier, and these contain the formulæ and other explanations of his planetary and other investigations, as well as memoirs by some of his assistants. The section of Observations, of which there are also a large number of published volumes, contains the original notes of the observers, and the reduction of the daily observations. The publication of the *Annales* was discontinued during Le Verrier's absence from the Observatory, but it was resumed soon after his reinstitution to the Directorate in 1873 by M. Thiers after the death of M. Delaunay.

Though so purely a mathematician, and a comparative stranger to the practical duties of an observatory, Le Verrier, in 1854, soon became personally acquainted with the details of the instruments, all of which were, however, of inferior construction. On this subject he complains in the first volume of the *Annales de l'Observatoire* of the lamentable deficiency

of the instrumental means of the Observatory during the last century; and even to so recent a date as 1828 the principal transit-instrument was a very poor specimen of a meridional telescope in a great national Observatory. Commenting on this instrumental poverty of the Paris Observatory during the last and first half of the present centuries, Professor Pritchard has remarked 'that in the imperial city, long adorned by the genius of Laplace and Lagrange, until the year 1800 there was no transit-instrument of any description existing within the walls of the Observatory. It is still more incredible that, up to the year 1828, the instrument then provided was inferior to that with which Bradley had verified his immortal discoveries, and had laid the foundation of modern astronomy some seventy years before. Moreover, at the very time when the great transit-circle at Greenwich was in full operation, there was not a telescope within the Paris Observatory admitting as much as the fourth part of the light which was then brought to the focus of the noble instrument at the disposal of the English Astronomer Royal, and constructed after the model proposed by himself. . . . All this unfortunate deficiency M. Le Verrier, immediately after his appointment, set himself diligently to repair, with the noble ambition of entering, as he says, "upon a pacific contest with other nations, for a place in the foremost rank of astronomical fame, and for the recovery and maintenance of the scientific renown of France." The present reputation of the Imperial Observatory, and the high and undoubted estimation of its *Annales* by foreign astronomers, cannot fail to

furnish, even to the laudable ambition of its Director, a satisfactory proof that these hopes have been fully realised.'[1]

As may be inferred from the preceding remarks, Le Verrier was soon convinced that the Observatory could not hope to compete successfully with others without a considerable modification of the ancient instruments, especially of those in daily use. The first to receive attention were the transit-instrument and the mural-circle of Gambey, in both of which some important improvements were made. In the mural-circle a grave fault of construction was discovered, affecting most seriously all the observations of polar distance made with it. This defect was known to Arago some time before his death, for which reason the observations were never completely reduced during his life-time, as he believed that they were too injuriously affected to be of much ultimate value. In Le Verrier's hands, however, many of the difficulties which made Arago hesitate were removed, and the observations and reduced places may now be found in the observational section of the *Annales*. The two ordinary meridional instruments having been successfully cleared of their defects, Le Verrier directed his attention to another class of instruments, more suitable to the modern requirements of astronomy. He was particularly desirous to inaugurate a systematic scheme of observations of the minor planets on the meridian, but he found that the exist-

[1] Address of Professor Pritchard, F.R.S., on presenting the Gold Medal to M. Le Verrier, 1868. *Monthly Notices, R.A.S.*, vol. xxviii. p. 112.

ing instruments had not sufficient aperture to permit the observation of the fainter members of the group. He therefore obtained the authority of the Government to erect a large transit-circle, equal in penetrating power to the similar instrument at the Royal Observatory, which was first brought into use at the beginning of 1851. The object-glass of the Greenwich transit-circle has an aperture of eight inches, but that at Paris is about nine inches. This additional inch of aperture has been proved to be of great importance, as many of the minor planets, which have been found impossible to observe with the Greenwich transit-circle, owing to their extreme faintness, have been easily detected with the Paris transit-circle. As soon as this instrument came into use, a convention or agreement was made between M. Le Verrier and the Astronomer Royal, for the mutual observation of the minor planets, by which it was arranged, for the convenience of both Observatories, that all the asteroids for which meridional ephemerides were calculated, should be observed at Greenwich during the first half of each lunation, or between New Moon and Full Moon, and at Paris during the second half of the lunation, or between Full Moon and New Moon, limiting the time of observation to the interval between ten P.M. and one A.M. This mutual observation of the minor planets has been in practice since October 1863. An excellent equatoreal and several other important instruments were also added to the equipment of the Observatory. An equatoreal of the largest class was in progress of construction at the time of Le Verrier's death, at the expense principally

of a wealthy patron of astronomy and Paris banker, M. Bischoffsheim.

The daily publication of the *Bulletin International*, compiled under the direction of M. Le Verrier, and arranged on a similar plan to the weather tables issued in England by the Meteorological Council of the Board of Trade, has been found to be of great scientific as well as national importance. The daily concentration of so much data concerning the ever-changing condition of the meteorological elements, collected by telegram from stations situated in all parts of France and from several other European countries, when placed in the hands of so great an authority, could not eventually fail to produce results of the highest value in connection with the climate of Western Europe. Le Verrier was accustomed to insert brief notices in the *Bulletin*, announcing the discovery and the approximate positions of new planets and comets, or of any other astronomical phenomenon likely to be of interest.

At the latter end of 1853 a most successful determination, in two series, of the difference of longitude between Greenwich and Brussels, was made, by means of the simultaneous observation of the local time, at both stations, of the deflection of the needle of a galvanometer, caused by the transmission of a galvanic current along the telegraphic wire connecting the two Observatories.[1] The plan of operation was arranged beforehand by the Astronomer Royal and the late

[1] In the first series the observations were made by M. Bouvy at Greenwich, and by the author at Brussels; in the second series the observers were interchanged.

M. Quetelet, and a new value of the difference of longitude was obtained, which has since been received with the greatest confidence. This experimental determination of telegraphic longitude had only been completed a short time, when M. Le Verrier proposed that the operation should be repeated between Greenwich and Paris, also in two independent series, at an early convenient opportunity. This subject had been proposed by the Astronomer Royal to M. Arago two years previously, but for various reasons was never carried out. One of Le Verrier's first actions, therefore, after taking up his residence at the Observatory, was to accept the Astronomer Royal's proposition which had been submitted to his predecessor in 1851, and principally through his active assistance it was soon brought to a successful conclusion.

This second galvanic determination of the difference of longitude between the Royal Observatory and the Continental Observatories extended in each series over nearly a fortnight, the use of one of the ordinary telegraphic wires having been placed at the disposal of the Astronomer Royal in England, and of M. Le Verrier in France, during one hour on each evening. The observations were carried through with a completeness and accuracy unknown in former determinations, and the success of the operations was mainly due to the energetic manner with which Le Verrier entered upon all his share of the details of the work; and by his personal influence at the French Bureau des Télégraphes many difficulties that unexpectedly occurred during its progress were easily surmounted. The observations of the available

signals during the first series commenced on May 27, 1854, and terminated on June 4; the two observers[1] were then interchanged for the second series, which commenced on June 12 and ended on June 24; the number of the observed signals used in the determination being about 1,700. The signal-times recorded on the evenings when no satisfactory clock-error was obtained at either Observatory were rejected. The deduced difference of longitude resulting from the observations is $9^m\ 20^s{\cdot}63$, differing nearly one second from that previously found by means of rocket-signals. By this latter method the probable error of the result is, however, far greater than that of the telegraphic determination. Several other differences of longitude between the Paris Observatory and some of the principal towns in France were subsequently determined under the superintendence of Le Verrier, by means of the telegraphic method, with the most satisfactory results.

M. Le Verrier took a great interest in the success of l'Association Scientifique de France. As its president and originator, he was the principal conductor of its affairs, and superintending editor of its publications. This institution, like the British Association for the Advancement of Science, holds its annual meetings in different towns in France, and it has been found to have created more than a passing interest in scientific research in districts where science had hitherto been neglected.

[1] On this occasion the Paris Observatory was represented by M. Faye, and the Royal Observatory by the author. All the observations, both of clock-stars and galvanic signals, were made by these observers.

As might have been expected, honours of all kinds were conferred on M. Le Verrier, both political and academical. In 1849 he was elected a member of the Legislative Assembly, where he was always the advocate or promoter of laws for the regulation and extension of public education, and for the advancement of science. In politics he was a Conservative and a supporter of the Imperial dynasty, which secured for him, in 1852, a life appointment as Senator, and a seat in the Superior Council of Public Instruction, offices which he retained till the fall of the Emperor Napoleon in 1870. M. Le Verrier was the recipient of many foreign orders of merit given in acknowledgment of his success as a scientific investigator; and in his own country he attained the high dignity of 'Grand Officier' in the Legion of Honour. He became a member of the Academy of Sciences in January 1846, in which year he was also elected an Associate of the Royal Astronomical Society, and subsequently a member of the Bureau des Longitudes, and a foreign member of the Royal Society. In addition to these, his name was also enrolled among the foreign members of nearly all the principal European Academies and Societies. From the Royal Astronomical Society we have already mentioned that he received a gold medal for his planetary researches in 1868, and again in 1876. The Council of this Society also awarded him, in 1848, a framed testimonial, in conjunction with Professor Adams, for his researches in the problem of inverse perturbations leading to the discovery of the planet *Neptune*. For the same investigation the Royal Society presented

him with the Copley Medal, one of its highest honours awarded to original workers in science. The honorary degree of Doctor of Laws was conferred on M. Le Verrier in 1875 by the University of Cambridge, as an acknowledgment of his great mathematical abilities.

The death of M. Le Verrier took place on the morning of Sunday, September 23, 1877. His health had been in an indifferent state for some years, and during the last six months of his life he was unable to take part in the weekly meetings of the Academy of Sciences, at which he had always been a regular attendant. In the beginning of August he appeared much better, and strong hopes were entertained by his friends that he would soon return to his accustomed duties at the Observatory. But eight days before his death most violent and depressing symptoms presented themselves, from which he never rallied. By the zealous attentions of his colleague and assistant, M. Gaillot, he was enabled to see the last proof-sheets of the tables of *Neptune* before the end came; so that he had the satisfaction of knowing that there was now nothing remaining of his planetary researches to finish, and that what was the desire of his life was accomplished, and his work was complete.

M. Le Verrier was interred in the cemetery of Mont Parnasse on the morning of the Tuesday following his death. 'The funeral *cortége* left the Observatory under a military escort with muffled drums—as usual at the funeral of a Grand Officer of the Legion of Honour—proceeding by way of the

Avenue de l'Observatoire and Rue Val-de-Grâce to the church of Saint Jacques-du-Haut-Pas, where the religious ceremony took place in the presence of a crowded assembly.'[1] The cordons of the pall were held by some of the leading men of science in Paris, representing most of the scientific institutions ; among these, English science was represented by Mr. J. R. Hind, F.R.S., Superintendent of the *Nautical Almanac.* At the grave, eulogic discourses were delivered by MM. Dumas, Faye, Janssen, Tresca, and Yvon Villarceau. Madame Le Verrier, whose health was failing at the time of her husband's death, survived him only a few months.

The organisation of the Paris Observatory has undergone some modification since the death of M. Le Verrier. Admiral Mouchez, well known as the Chief of the French Expedition to the island of St. Paul for the observation of the transit of *Venus* in 1874, has been appointed his successor, taking charge principally of the administration of the Observatory. M. Tisserand, formerly of the Observatory at Toulouse, has been selected to fill the office of Assistant-Director,[2] and to undertake the general control of the scientific work. One of the most important of the changes is the discontinuance of the preparation of the daily meteorological bulletin, in the success of which Le Verrier had always been so much interested. The compilation and issue of this valuable record of the daily conditions of the atmosphere, as well as the

[1] *Monthly Notices, R.A.S.*, vol. xxxviii. p. 166.

[2] M. Tisserand has also been chosen as the successor of M. Le Verrier in the Academy of Sciences.

control of other meteorological work, have now been transferred to a separate department, under the charge of a staff of officers independent of the Director of the Paris Observatory.

We cannot more appropriately close this slight notice of the scientific career of this distinguished astronomer than in the words of M. Villarceau, who was the official colleague of Le Verrier at the Observatory during the whole of his Directorate :—'La vie de Le Verrier fut presque entièrement consacrée à la science astronomique: la postérité maintiendra son nom à côté de ceux de Newton et de Laplace. Le plus grand honneur que l'on puisse faire à sa mémoire sera de contribuer, comme il l'a fait, à l'avancement de la mécanique céleste et au perfectionnement des instruments et des méthodes d'observation : je crois être l'organe de mes collègues de l'Observatoire en affirmant que tel est leur plus vif désir. En voyant se continuer les traditions scientifiques que Le Verrier nous a laissées, sa veuve et ses enfants auront au moins la consolation de penser que la mémoire de celui qu'ils viennent de perdre est toujours vivante à l'Observatoire. Adieu, grand astronome ! adieu !'

PROFESSOR KARL L. VON LITTROW.

1811–1877.

KARL LUDWIG VON LITTROW was the son of Professor J. J. von Littrow, formerly Director of the Imperial Observatory at Vienna, and the author of several important papers on astronomical and physical subjects, some of which were contributed to the Royal Astronomical Society, and may be found in the first four volumes of the *Memoirs*. Before Dr. J. J. von Littrow's appointment in 1819 to the Observatory at Vienna, he held the Professorship of Astronomy in the University of Kasan, where his son Karl was born on July 18, 1811. The elder Littrow personally superintended the education of his son from an early age, and thus the latter soon acquired an inclination for astronomical pursuits, which ultimately led him to follow in the footsteps of his father as a professional astronomer. On the completion of his education, he accepted, in 1831, the position of Assistant-Astronomer in the Imperial Observatory of Vienna.

A few years after his appointment to the Observatory, Dr. Karl von Littrow made a very valuable contribution to the history of astronomy by his publication of Father Hell's account of his observations of the transit of *Venus* in 1769 at Wardoe, derived from that observer's original day-book, to which his official posi-

tion gave him access. This work, *Reise nach Wardoe bei Lappland und seine Beobachtung des Venus-Durchganges im Jahre* 1769, was published in 1835, and it gives a faithful transcript of Hell's apparently doubtful observations, which had formed the subject of much unfavourable criticism since the publication of Encke's treatise on the transit of *Venus* in 1769. By a careful examination of a *facsimile* copy of the original, Mr. Stone, in his recent discussion of the observations of that transit, was able to explain much that appeared to be doubtful, and to interpret the entries in such a manner as to show the probable truthfulness of the observations.[1] Soon after the appearance of this work, by which the name of the younger Littrow became known in astronomy, independently of that of his father, he made the first of his long series of communications to the *Astronomische Nachrichten* in the form of a note, containing the results of his observations of Halley's comet, followed by others of a similar nature; a class of equatoreal work to which most of his official attention was at this time more particularly directed. Both before and after his father's death, he was very interested in newly-discovered planets and comets, and he has published several extensive series of observations of these telescopic objects. Of comets in particular, Karl von Littrow was a most assiduous observer; and without giving in detail the names of the minor planets and comets whose places he determined during the earlier part of his connection with the Vienna Observatory, it may be remarked that in the

[1] *Monthly Notices, R.A.S.*, vol. xxviii. p. 256.

Astronomische Nachrichten alone may be found the results of his equatoreal observations of more than thirty comets. In addition to his observations of many of the early-discovered minor planets, he also published several sets of elements of their orbits. In 1843 he made a valuable series of observations of the great comet discovered in the spring of that year—an object which created an intense interest in England by the sudden appearance of its immense tail above the south-west horizon, while the nucleus never became visible in this country. The observations of this comet, of Colla's comet of 1847, and also of other comets, were communicated to the Royal Astronomical Society, and they appear in the earlier volumes of the *Monthly Notices.*

In 1840 the office of Director of the Observatory of Vienna became vacant by the death of the elder Littrow, and there appears to have been some difficulty in finding a suitable successor. Karl von Littrow had, however, by this time distinguished himself as a painstaking observer, and, through the advancing age of his father, he had in some measure assisted in the control of the affairs of the Observatory. But, though he was qualified to undertake the position of Director, many would rather have seen the post filled by some astronomer of greater rank in the science; and thus the post remained vacant till 1842, when Karl von Littrow received the appointment to the office, and also to the Professorship of Astronomy in the University of Vienna, also held by his father. His qualifications for the office have since been well confirmed by his able administration during the thirty-five years

of his superintendence. During his long Directorate of the Observatory, the general operations of the establishment were confined chiefly to the class of work to which he had been so long accustomed, especially to observations resulting from new cometary and planetary discoveries, in the continued prosecution of which the Vienna astronomers have taken more than usual interest. Several important determinations of the elements of the orbits of particular comets have also been undertaken by Professor von Littrow and the assistant-astronomers, Hornstein, Oeltzen, and Weiss.[1] The *Annalen der Sternwarte in Wien* contain the results of many of the most important researches emanating from the Observatory, among which may be found Oeltzen's Catalogue of Argelander's northern zone observations of stars between 45° and 80° north declination reduced to 1842. This excellent catalogue appeared in two parts, one in 1851 and the second in 1852; and though it might with advantage be more conveniently arranged by the addition of columns with the annual precessions, so that the places of the stars might be more easily reduced to another epoch, still it has been found of great use to astronomers for the identification of many small stars observed with comets or other objects, but not included in other catalogues.

Professor von Littrow communicated several papers to the Vienna Akademie der Wissenschaften, which are printed in its *Sitzungsberichte.* He also frequently contributed to the proceedings of other societies. In the *Monthly Notices* there are several notes forwarded

[1] Dr. E. Weiss has been appointed to succeed Professor von Littrow, as Director of the Observatory of Vienna.

by him to the Royal Astronomical Society, including one on the rectification of equatoreals by observations of stars on the meridian and at an hour-angle of six hours; and another on a method of determining the latitude at sea. In 1864 he requested M. Faye to lay before the French Academy of Sciences a new method for determining the time and the longitude at sea, which was tried during the scientific voyage of the Austrian frigate, the 'Novara,' and adopted by Admiral von Wüllerstorf as part of the daily routine of the vessel. This method consists in the determination of the time by two circum-meridional observations of the Sun, preserving at the same time the observation of the true noon for latitude, the two altitudes being taken at pleasure on the same side or on the opposite side of the meridian. Professor von Littrow was also the editor of his father's well-known treatise on popular astronomy, *Die Wunder des Himmels*, which has passed through several revised editions. This work is divided into four parts, the first of which treats of theoretical astronomy; the second part relates chiefly to descriptive astronomy and the topography of the heavens; the third is devoted to physical astronomy; while the fourth refers to the explanation of the construction and use of astronomical instruments. The atlas, which forms a suitable addition to the work, *Atlas des gestirnten Himmels für Freunde der Astronomie*, has also been revised by Dr. Karl von Littrow.

It was principally through the representations of Professor von Littrow that the Imperial Academy of Sciences at Vienna proposed, in 1869, a scheme for

awarding a series of prizes, limited to eight annually, for the discovery of telescopic comets during the three years' interval between May 31, 1869, and May 31, 1872. The prizes awarded consisted either of a sum of money—twenty Austrian ducats—or of a gold medal of equivalent value. The scheme was faithfully carried out, and before Professor von Littrow's death it was resolved by the Academy to continue the prizes for another term.

The situation of the Vienna Observatory, in the midst of narrow streets, had long been felt as a serious hindrance to the prosecution of any delicate astronomical work. This Observatory was erected in 1826–27, under the superintendence of Professor J. J. von Littrow, on the site of the original Observatory, founded in 1753 by Father Hell, the first Director. The requirements of modern astronomy in a first-class national Observatory having so much increased since the erection of the second building, Professor Karl von Littrow was induced to represent to the Austrian Government the desirability of removing the Observatory to a more favourable position outside the city, but still at a convenient distance from it. The advantage of the transfer was at once acknowledged, and his recommendation was acceded to. In 1873 the official sanction of the Minister of Public Instruction was obtained for the erection of the present building, which is capable of accommodating instruments of the largest construction, furnished with every astronomical appliance required in the pursuit of meridional, equatoreal, or physical observations. The spot selected for the new Observatory is situated

about three miles to the north of the centre of Vienna. The foundation stone was laid in June 1874, and, at the time of Professor von Littrow's death, the building was far advanced towards completion. Though he was not permitted to see the full effects of the change in the position of the Observatory, the forward state of the works enabled him to form some idea of the advantages which his successors would enjoy by the increased accommodation, and by the absence of the noise and dirt which so injuriously affected the observations made in the former building. An illustrated description of the new Observatory by Mr. De La Rue, F.R.S., written in 1875 after a personal inspection of the works, is inserted in vol. xxxvi. of the *Monthly Notices* of the Royal Astronomical Society. The great refractor of twenty-six inches aperture, constructed by Mr. Howard Grubb, of Dublin, will be a great addition to the instrumental equipment of the Observatory.

Professor von Littrow was a corresponding member of several foreign academies, and, since April 1853, he was an Associate of the Royal Astronomical Society. For some time before his death his health was not very satisfactory, and his friends were in consequence extremely anxious concerning him. He was advised to seek a change of scene, and to retire for a time to Venice, where he died on the morning of November 16, 1877, in the sixty-seventh year of his age. In 1878 his friends and colleagues caused a medal to be struck to his memory, having on the face a portrait of Professor von Littrow, and on the reverse a view of the new Vienna Observatory.

REV. ROBERT MAIN, F.R.S., RADCLIFFE OBSERVER.

1808—1878.

THE REV. ROBERT MAIN, M.A., F.R.S., was born at Upnor, Kent, on July 12, 1808. He received his early education at a private school at Portsea, conducted by the Rev. J. Neave, who had the reputation of being an excellent mathematician. The memory of this gentleman was always held in great respect by Mr. Main, who attributed his own acquired taste for mathematical pursuits to the preliminary training he received under his care. Through the influence and advice of Mr. Neave, he was induced to continue his study of higher mathematics, with the ultimate object of becoming a student in the University of Cambridge. On leaving school, his advancement in life depending on his own exertions, Mr. Main obtained employment as an assistant-master in the Grammar School at Bishop's Waltham, Hants. Here, by the strictest economy, he was enabled to accumulate sufficient savings out of his small stipend to place his name on the books of Queens' College, Cambridge, where, during his undergraduate course, he highly distinguished himself, and obtained a foundation scholarship. In 1834 he graduated as B.A. with the high position of sixth Wrangler, Professors Kelland

and Birks being respectively the senior and second of his year. Very shortly afterwards Mr. Main was elected to a Fellowship of Queens', which he, however, relinquished in 1838 on his marriage.

In consequence of the resignation in 1835 of Mr. Pond, F.R.S., Astronomer Royal, and the appointment of Professor Airy, F.R.S., Plumian Professor of Astronomy in the University of Cambridge, as his successor, a vacancy also occurred in the office of First Assistant at the Royal Observatory. The former First Assistant, Mr. Thomas Taylor, who had held the office since 1805, had retired on superannuation, and Mr. Main, who had not then entered into holy orders, was selected to fill the place. He was recommended most strongly to the new Astronomer Royal as a young graduate of high standing as a mathematician, and well fitted in other respects for so important a charge. Sir George Airy, at the beginning of his official connection with the Royal Observatory, now (1879) forty-four years ago, was thus extremely fortunate in obtaining the services of Mr. Main as his confidential assistant, who, during his twenty-five years of office at the Royal Observatory, never failed to carry out his instructions with the strictest official integrity, which was indeed a marked feature in his character.

Mr. Main entered upon his duties at the Royal Observatory with considerable energy of spirit, and the Astronomer Royal found in him a ready helpmate in assisting him to carry out the new regulations he had introduced to sustain the reputation of the Observatory in the rapidly advancing state of astro-

nomy. One of the most important changes introduced at this time, and which has proved to have been of great service to astronomers, was the new form of printing the original observations and details of the reductions, so advantageously adopted by Professor Airy when he was in charge of the Cambridge Observatory. The arrangement in separate columns on each page of the successive steps in the calculations, enables any one to examine with ease in the printed volumes the whole of the work leading to the result, commencing with the original readings made at the time of observation, and continued throughout the whole process of reduction. It is owing to this successful innovation in the form of printing the volumes of the *Greenwich Observations*, which has received the universal approbation of astronomers, that the labours of mathematicians, such as Hansen, Le Verrier, and Adams, who have had occasion to employ the Greenwich results in their researches, have been considerably lessened. No one could have taken more interest in carrying out the superintendence of this official work than Mr. Main; and he never spared himself, for he was always willing to take his share of the more mechanical sections of the computations, particularly of those relating to the extra-meridional observations. Those who have examined the astronomical contents of a volume of the *Greenwich Observations* must have noticed that they are divided into sections, some containing the observations and reductions with reference to objects observed on the meridian; others referring to observations made with the altazimuth or with the equatoreals; and the final section of results containing

the comparison of the observed and tabular places of the Sun, Moon, and planets, and the deduced errors of longitude and ecliptic north polar distance. It was the usual duty of Mr. Main, during his connection with the Observatory, to superintend personally most of the advanced calculations which form the details printed in this section of astronomical results, and he was accustomed to compute or examine all the more critical portions. What he did in this respect, and in the usual daily calculations, is known to few at the present day, but it is all recorded in the manuscript volumes preserved in the archives at the Royal Observatory; and even down to 1860, the year of his appointment as Radcliffe Observer, his signature may be noticed in the ordinary books of calculations as an occasional examiner of the daily meridional work. Indeed Mr. Main's reputation as a computer, and as a superintendent of computers, has been acknowledged out of the Observatory by all who have examined the contents of his numerous contributions to the Royal Astronomical Society. His natural inclination for work of this kind encouraged him at times to undertake computations that might have been profitably relegated to a young and less skilled assistant; and he has been known to revel for days together over computations requiring only the simplest rules of arithmetic. His removal to Oxford made no alteration in his habits in this respect. Even there he always took his full share of the ordinary calculations, especially of the reductions of the transit observations; while those requiring extra care and attention, as the reductions of the occulta-

tions of stars by the Moon, &c., were specially reserved for himself, as stated in the introduction to the *Radcliffe Observations*. Till about the year 1872 he also prepared his own measures of double stars and diameters of planets for the press. It must, however, be remembered that the staff of assistants at the disposal of Mr. Main at Oxford was a small one, and that he found it necessary to contribute his own computing energies to the work of the Observatory to enable the annual volume of the *Radcliffe Observations* to appear with regularity.

During the time that the Rev. R. Main was First Assistant at the Royal Observatory, he contributed a number of valuable papers to the Royal Astronomical Society, consisting principally of deductions from the data contained in the different sections of the *Greenwich Observations*, both planetary and sidereal. His first memoir was undertaken to correct the elements of the orbit of *Venus*, by comparing the Cambridge and Greenwich observations of that planet from 1833 to 1836, with the tabular places given in the *Berlin Ephemeris* for 1833, and in the new series of the *Nautical Almanac* from 1834 to 1836. From this first and preliminary investigation, he deduced corrections to the node and inclination of *Venus*; and in a table he exhibited the effect of the substitution of these corrections on the original observed errors of the tables. In a second communication Mr. Main continued his discussion of the same observations, with reference to the mean distance, excentricity, epoch, and longitude, and determined the corrections to each element. The details of these investigations,

together with those of a continuation by Mr. James Glaisher, F.R.S., are given in the *Memoirs* of the Royal Astronomical Society.

Of the Rev. R. Main's numerous communications to the Royal Astronomical Society, few have been more frequently quoted than his series of memoirs containing the investigations of the Proper Motions of the stars observed at the Royal Observatory in the middle of the last century by Dr. Bradley, then the Astronomer Royal, the reduced right ascensions and declinations of which for 1755 are given in Bessel's *Fundamenta Astronomiæ*; and those on the form and dimensions of the planet *Saturn* and its system of rings. Three separate catalogues of the proper motions of the Bradley stars were presented to the Society. The first of these contains the proper motions of 875 stars common to the *Fundamenta Astronomiæ* and the *Greenwich Catalogue of* 1,439 *Stars*. It includes all the fundamental stars in the list of the *Nautical Almanac*; most of the conspicuous stars that fall in the path of the Moon during a whole revolution of the node; and also a considerable number of stars that pass the Greenwich meridian a few degrees north and south of the zenith, which are useful either for the determination of the constant of refraction, or for geodetical operations. The second list of proper motions also contains a large number of stars useful for many purposes, taken from the second part of the *Twelve-Year Catalogue*. These two catalogues of proper motions are inserted in the same memoir, but the corresponding tables are kept separate. Mr. Main has divided each memoir into

three parts, the first containing the complete list of stars, with the corresponding number in the *Fundamenta* affixed. Columns are also given for the correction to Bessel's precession, the mean precessional motion according to Otto Struve's and Peters's determination, the mean annual motion as deduced from a comparison of the two catalogues, and the resulting proper motion. In the second part he has selected all the stars whose proper motions are greater than $0^s{\cdot}005$ in right ascension, and $0''{\cdot}1$ in north polar distance; while in the third part he has given a list of those stars which have proper motions exceeding $0^s{\cdot}02$ in right ascension, and at least $0''{\cdot}3$ in north polar distance. These three parts in the two memoirs contain, therefore, the proper motions of all the Bradley stars common to the *Fundamenta* and the *Greenwich Twelve-Year Catalogue of* 2,156 *Stars*. The method of reduction employed by Mr. Main consisted simply in calculating for each star the difference between the mean annual observed motion in right ascension and north polar distance, from 1755 to the epochs of the modern catalogues, and the corresponding mean annual precessions in both elements deduced from Struve's and Peters's constants. This combined memoir is inserted in vol. xix. of the *Memoirs*. In the second memoir on this subject the proper motions of the Bradley stars in the *Greenwich Six-Year Catalogue of* 1,576 *Stars* for 1850, but not included in the former catalogues, are determined by the same formulæ as before. In this new list of proper motions several of the stars are particularly valuable, including some which had been recently

selected as special clock-stars, for the determination of the error of the clock; stars in the constellation *Canis Major* compared with *Sirius*; stars near the pole used for determining azimuthal errors; and a few having unusually large proper motions. Mr. E. J. Stone, F.R.S., Mr. Main's successor at Greenwich, continued these investigations in relation to the Bradley stars, contained in the *First Seven-Year Catalogue of* 2,022 *Stars* for 1860, not previously observed. These Greenwich values of proper motion, computed by Mr. Main and Mr. Stone, have hitherto been generally adopted.[1]

On March 9, 1849, Mr. Main read a paper before the Royal Astronomical Society on the form of the planet *Saturn*, as deduced from micrometric measures made by him in the preceding year when the rings were invisible. The measures were made by the Airy double-image micrometer, attached to the Sheepshanks equatoreal at the Royal Observatory, with a twofold object: first, to determine, as accurately as the method permitted, the true ellipticity of *Saturn*; and secondly, to ascertain whether any sensible deviation exists in its figure from a perfect ellipse. His results show that, by the most refined measures, no deviation or irregularity of form could be detected in

[1] Dr. Auwers, of Berlin, has made a fresh reduction of Bradley's observations of stars, in which he has been materially assisted by the loan of a copy of the original observations preserved at the Royal Observatory, by means of which he has detected several errors overlooked by Bessel. We understand that this important work is approaching completion, and that it will contain a new determination of proper motions, which will most probably supersede those based on the old edition of the *Fundamenta Astronomiæ*.

the planet; and Mr. Main suggests that an apparent distortion, noted by Sir William Herschel, was probably due to some optical peculiarity in the atmosphere surrounding *Saturn*, or from some illusion produced on the eye by the rings of the planet. The resulting value of the ellipticity of *Saturn*, $\frac{1}{9\cdot337}$, has been received with much favour, and is believed to be sensibly correct. In the winter of 1852–3, at the beginning of 1854, and in December 1855, Mr. Main also made three careful series of measurements of the rings of *Saturn* with the same instruments at the Royal Observatory, the results of which form the subject of a communication to the Royal Astronomical Society, read on December 14, 1855. In it he compares his measures with those previously made by Otto Struve, and points out to what extent they differ. The separate values which Mr. Main found after an exhaustive discussion of the measures are:—the diameter of the exterior edge of the outer ring, 39″·73; the diameter of the inner edge of the inner ring, 27″·65; and the equatoreal diameter of the ball of the planet, 17″·50. These angular values, in his opinion, represent with tolerable accuracy the dimensions of the *Saturnian* system, and prove that no change whatever in the relative position of the rings has taken place since the time of Huyghens. This memoir was followed by an equally important paper on the values of the diameters of the planets having measurable disks, also determined with the Airy double-image micrometer attached to the Sheepshanks equatoreal at the Royal Observatory. This memoir consists of a systematic discussion of all the measurements of

the diameters of *Mercury*, *Venus*, *Mars*, and *Jupiter*, made by Mr. Main from time to time during the years 1840 to 1852, to which he has added in a supplement some more recent measurements of *Mars*. In a synoptic table of results, he gives the observed angular equatoreal diameters at unit of distance, and also in miles, for the four planets, with the deduced values of the ellipticity of *Mars* and *Jupiter*.

Other semi-official contributions to the Royal Astronomical Society, prepared partly at the suggestion of the Astronomer Royal, were at different times communicated by Mr. Main, all of which are discussions of the results of observations made in the usual course of daily work at the Royal Observatory. With these we may include his memoirs on the value of the constants of aberration and nutation, and of the parallax of γ *Draconis*, determined from eleven years' observations made with the old twenty-five feet zenith tube, now dismantled, and from eight years' observations made with the reflex zenith tube; also that on the value of Bessel's constant of refraction, a discussion founded on the north polar distances of stars observed near the zenith and the north and south horizon from 1836 to 1854; and another on the variability of the proper motion of *Sirius*.

Mr. Main's memoir on the constants of nutation and aberration, &c., was an attempt to utilise the observations of the well-known star in the constellation *Draco*, which culminates on the meridian near the zenith of Greenwich. These observations were made with tolerable continuity between June 1837 and May 1848, the only interruptions being those

caused by long periods of bad weather, daylight, or when the instrument required re-adjustment or repair. The time devoted by Mr. Main to the preparation of this memoir was considerable, as we may judge from the fact that the results involved the solution of 161 equations of condition, each of which represented a group of observations rarely extending over an interval of time greater than fourteen days; the mean value of this group being assumed to correspond accurately with the mean of the days of observation. From some unexplained cause, however, the results of this laborious investigation were so anomalous that they have failed to add to our previous knowledge of the value of the constants under discussion; and, what is remarkable, the value of the annual parallax deduced from the observations has the negative sign, which at once indicates the untrustworthiness of the original data on which the investigation is founded. Probably some constant error of a periodical nature injuriously affected the observations, arising from a possible defect in the adjustment of the object-glass, the micrometer, or some other part of the instrument. Though the results were unsuccessful, the memoir is an important one, and it is valuable in some measure as showing that even a long series of apparently unexceptionable observations, accordant in themselves, may still be subject to a constant error of sufficient magnitude to vitiate the final result. On this subject Mr. Main himself remarks that 'the labour bestowed upon the investigation, in the endeavour to produce the best possible result from the observations by applying

rigorously the method of least squares, has been very great; and, as the whole of the calculations have been performed by myself, I regret much that the results have not proved so unexceptionable as to warrant the amount of care and labour expended. Still a laborious work of this kind cannot be without its value.' In Mr. Main's second paper, using the observations with the reflex-zenith tube, the resulting value of the constant of aberration is more satisfactory; but he still obtained a negative parallax, showing that this instrument, though in theory it is free from most of the instrumental defects of the old zenith tube, is also subject to some constant error, arising from atmospheric or other circumstances.

The tables of refraction which have been generally used in most observatories have been those given by Bessel in the *Tabulæ Regiomontanæ*. These tables have been expanded in a more convenient form for practical use in the Royal Observatory, and published as an appendix to the volumes of the *Greenwich Observations* for 1836 and 1853. In 1857 Mr. Main undertook to investigate the degree of accuracy with which Bessel's tables represented the Greenwich observations of the north polar distances of stars. To obtain the necessary material for his purpose, he extracted from the *Greenwich Twelve-Year Catalogue* and the subsequent available star catalogues, all the reduced north polar distances of the southern stars whose meridional zenith distances are greater than seventy degrees, and of all the circumpolar stars whose zenith distances at their transit beneath the pole are also greater than seventy degrees. To ob-

tain proper corresponding southern stars observed near the horizon at Greenwich and near the zenith at the Cape of Good Hope, Mr. Main made use of the determinations only of stars which were common to both Observatories, each being reduced with exactly the same elements of refraction, on the assumption that the constant is not affected by locality. The general result of the discussion of these observations appears to show that Bessel's refractions satisfy all the observations of stars situate between the zenith and eighty-two degrees zenith distance, or of greater altitude than eight degrees, but that the refractions of all objects below that point require to be slightly diminished by a quantity which Mr. Main considered is of sufficient magnitude to be taken into account in the computation of the refraction of stars near the horizon. From a more recent inquiry into this subject, it seems evident that our knowledge of the true refraction at very low altitudes is still imperfect, and that the observations are too scanty to decide this important question, especially as the very large probable error of the observations of stars within five degrees of the horizon tends to vitiate any result depending on the few available observations for such a research. It may be remarked, however, that the observations made by Mr. Henderson at the Cape Observatory also showed that Bessel's refractions at low altitudes were too great.

Mr. Main's memoir on the variability of the proper motion of *Sirius* was undertaken to disprove an assertion made repeatedly by Professor Calandrelli, of Rome, of the incorrectness of the north polar dis-

tance of this star for the epoch 1845, given in the *Greenwich Twelve-Year Catalogue.* He succeeded in showing that the difference of the results derived from the observations made from 1836 to 1841, and from 1842 to 1847, noticed by Calandrelli, had not its origin in any error of observation or reduction, but that it resulted from a real fluctuation, most important and interesting. M. Laugier obtained a similar result from a comparison of the most trustworthy observations of the north polar distance of *Sirius*, made between the years 1690 and 1852. The variability of the proper motion of this brilliant star is now fully established, and it is probably due to the perturbations produced on *Sirius* by one or more companion satellites.

Among Mr. Main's communications to the Royal Astronomical Society having no relation to the Greenwich observations, one of the most important was a report drawn up in 1840, at the request of the Council, on the state of our knowledge of the parallax of the fixed stars. This report was esteemed so highly by the Council, for whose guidance it was written on the occasion of the award of the gold medal to M. Bessel for his researches on the annual parallax of 61 *Cygni*, that it was specially ordered to be printed in vol. xii. of the *Memoirs.* Sir John Herschel, whose duty it was to deliver the address on the presentation of the medal, acknowledged his great obligations to Mr. Main for being allowed to draw so freely on this exhaustive report, which is, as far as he could judge, a complete and admirably drawn-up monograph of the whole subject. Mr.

Main considered the general question of parallax under four divisions:—1. Abstracts of theoretical papers on the subject; 2. A statement of the results of observations made since the time of Bradley; 3. A review of the results deduced by contemporaneous astronomers; 4. A discussion of Bessel's observations and results. The historical part of the report gives evidence of great research, and the special observations and deductions of Bessel are given and explained with much clearness. From a careful discussion of the tables and graphical illustrations given in the report, Mr. Main concluded 'that not only has a real parallax been detected in the double star 61 *Cygni*, but that its amount is very approximately given in Bessel's investigation, who is enabled, by repeating the same process, to diminish at pleasure the residual errors of the determination.'

In January 1846 Mr. Main read a paper before the Royal Astronomical Society on the reduction of a number of sextant observations of the distance of the great comet of 1843 from certain bright stars, which had been communicated to the Society by various observers. Though observations of this kind are not so valuable as when they are made by fixed instruments, yet it was considered, with respect to this remarkable comet, whose tail only was visible in England, that careful observations made with the sextant might prove to be of some use in the calculation of its orbit. At the request of the Council, Mr. Main undertook the superintendence of the reductions, as a duty properly falling upon him as one of the Honorary Secretaries. The computations, which

involved the solution of several hundred spherical triangles with seven-figure logarithms, were performed by Mr. Harris, then Assistant Secretary, at the expense of the Society, and examined by Mr. Main, with the assistance of two of his colleagues at the Royal Observatory. The details of all the observations and the results of the calculations are given in the memoir, together with the formulæ employed in the reductions.[1] Among his other private communications to the Society, we ought to allude to his interesting remarks on the physical peculiarities of some of the principal comets, including those observed in 1744, 1769, 1811, 1835 (Halley's), and 1858 (Donati's). By a series of diagrams prepared by Mr. Main, he showed that the peculiar appearances which all these comets exhibited as they approached their perihelion were so similar, that the drawings of the head and nucleus of any one comet would fairly represent all the others; but, in his opinion, the superior drawings and elaborate descriptions of Donati's comet rendered it a much more scientific subject for study than any which preceded it.

In 1859 Mr. Main presented to the Royal Astronomical Society a very interesting communication on the state of the controversy respecting the amount of the acceleration of the Moon's mean motion, in which the history to that time of this difficult question is treated in the most impartial manner. In a subsequent note he continues the discussion, principally, however, in reply to an article by Dr. Hartwig, of Schwerin, in which some criticisms on Mr. Main's

[1] *Memoirs, R.A.S.*, vol. xvi. pp. 23–53.

remarks appeared. As the President of the Society, it was his duty to deliver the addresses on presenting the gold medal in 1860 to Professor Hansen for his *Tables de la Lune*, and in 1861 to M. Hermann Goldschmidt for his discovery of thirteen minor planets. Through the indisposition of Mr. Bishop, F.R.S., Mr. Main also delivered the address in 1859 on presenting the medal to Mr. R. C. Carrington, F.R.S., for his *Redhill Catalogue of Circumpolar Stars.* These addresses are excellent specimens of the literature of astronomy, independently of being clear expositions of the grounds on which the medals were awarded.

Mr. Main's self-imposed labours in the cause of astronomy, while First Assistant at Greenwich, were duly appreciated by most of his contemporary astronomers. His friend and predecessor at Oxford, Manuel J. Johnson, F.R.S., on presenting him with the gold medal of the Society on February 12, 1858, thus refers to the extent of his endeavours to deduce from the Greenwich observations certain special results of interest:—'I have endeavoured, very imperfectly, to point out to you the nature and extent of Mr. Main's exertions, and how completely they have been directed to the development of the Greenwich observations, in a way which, consistently with its general duties, the Observatory could not attempt to pursue in its own publications. While, as astronomers, we rejoice that this important task has been performed by one who is in every respect fully qualified for it, we cannot, at the same time, fail to admire the energy and public spirit which has actuated its performance

amidst duties which to most men would of themselves appear sufficiently onerous.'[1]

On June 7 1860 Mr. Main was elected a Fellow of the Royal Society. He was a member of its Council for the usual period of two years, from November 1875 to November 1877.

In the summer of 1860 the vacancy caused by the sudden and lamented death of Mr. Johnson, on March 1 of the preceding year, was filled up by the appointment of Mr. Main to the important office of Radcliffe Observer at Oxford. He did not, however, cease his connection with the Royal Observatory till the end of September, when he was succeeded by Mr. Stone, Fellow of Queens' College, Cambridge.

When Mr. Main first went into residence at Oxford, he found that the first *Radcliffe Catalogue of Stars*, containing the results of all the star-observing from 1840 to the end of 1853, and reduced to the epoch of 1845 under the direction of Mr. Johnson, was nearly completed. A few sheets had already been printed and revised by Mr. Johnson, and after his death the remainder was carried through the press by the Principal Assistant, Mr. Quirling. Before proceeding to compile the introduction, Mr. Main felt it his duty to make himself acquainted with all the details of the computations, and to examine the accuracy of the constants and processes employed in the reductions, so that he might be in a position to hold himself, in some measure, responsible for the trustworthiness of this valuable catalogue, which his esteemed predecessor left to him as a legacy to com-

[1] *Monthly Notices, R.A.S.*, vol. xviii. p. 127.

plete.[1] A second *Radcliffe Catalogue*, containing the mean results, reduced to 1860, of the observations of stars from 1854 to 1861, made before the erection of Carrington's Redhill transit-circle, was compiled wholly under Mr. Main's supervision, and published in 1870. A third catalogue, containing about 4,400 stars, observed with the Carrington transit-circle, was considerably advanced at the time of his death, but its publication will probably now be delayed till the new Radcliffe Observer[2] has had time to examine the methods of computation, and to complete the work. The formation of these catalogues interfered but little with the publication of the annual volumes of the *Radcliffe Observations*, which have always appeared with the greatest regularity. Taking the volume for 1875 as an example, the last published under the supervision of Mr. Main, we find that the different sections contain:—Separate results for mean R.A. and N.P.D. of stars; catalogue of concluded mean R.A. and N.P.D. of stars for January 1, 1875; measures of distance and angle of position of the components of double stars, and of the diameters of *Mars*, *Jupiter*, *Saturn's* rings, and *Uranus*, made with the heliometer; observations and delineations of solar spots; occultations of stars by the Moon, and phenomena of *Jupiter's* satellites; and the results of the meteorological observations made during the year.

[1] This catalogue is peculiarly valuable, as it includes nearly the whole of the circumpolar stars observed by Groombridge.

[2] Mr. E. J. Stone, F.R.S., formerly First Assistant at the Royal Observatory, Greenwich, and afterwards Her Majesty's Astronomer at the Cape of Good Hope.

These sections are patterns of methodical arrangement, and so much of the observations and calculations as may reasonably be required are given in a convenient form for reference.

The superintendence of the observations and computations made at the Radcliffe Observatory absorbed nearly the whole of Mr. Main's time. Until the last few years he was accustomed to make all the measures of double stars, and of the diameters of planets, with the heliometer. He thus accumulated a large number of excellent measures of double stars, which, if formed into a combined catalogue, would become more available than they are at present in the pages of the long series of volumes of the *Radcliffe Observations*. During the unusually near approach of *Mars* in 1862, Mr. Main took the opportunity of making an extensive set of measures of its horizontal and vertical diameters, chiefly with the object of determining the ellipticity. At the unit of distance, his result gives for the equatoreal diameter 9″·377, corresponding to a real diameter of 4,175 miles, assuming the Sun's horizontal equatoreal parallax to be 8″·90. The observed ellipticity is $\frac{1}{37 \cdot 59}$. This important memoir is published in vol. xxxiii. of the *Memoirs* of the Royal Astronomical Society, and is the last of his papers inserted in that work. His later communications to the Society were mostly occasional short official notices, or detailed observations of the occultations of stars by the Moon and phenomena of *Jupiter's* satellites observed at the Radcliffe Observatory. He also jointly edited, with Professor Pritchard, at the request of the Council, Sir

John Herschel's posthumous index catalogue of double stars, forming vol. xl. of the *Memoirs.*

In 1852 Mr. Main published, as one of Weale's *Rudimentary Treatises,* an excellent little elementary book on astronomy, in which he endeavoured, in a semi-popular manner, to give a sketch of the methods and processes in use in the principal astronomical Observatories. One of its most important chapters is devoted to an explanation of the theory and mode of use of the instruments with which observatories are furnished. He also gives notes on the peculiarities of the Earth and planets, and a clear exposition of the general laws governing their movements within the solar system. Some years afterwards he made a translation of the first part of Brünnow's *Lehrbuch der Sphärischen Astronomie,* with the object of supplying a want which had been long felt at Cambridge and other Universities where astronomical studies are cultivated. This section of the work contains an explanation of the subjects most valuable to English students, especially the theories of parallax, refraction, aberration, precession, and nutation, all of which are given in a very complete form. The success of this translation induced Mr. Main to prepare a new work of a similar character, but still more suitable for the student. In 1863, therefore, his *Practical and Spherical Astronomy, for the use chiefly of Students in the Universities,* was published. In this most valuable treatise, Mr. Main has clearly explained the mathematical processes used in the reduction of various classes of astronomical observations, both meridional and extra-meri-

dional, particularly of those methods employed at a modern Observatory, so that students can readily make themselves acquainted with all the details that occur in the making and reducing of observations. So completely has he exhausted the subject, that Mr. Main considered that there is scarcely a process used at Greenwich, or at our other great English Observatories, left unexplained, and that an ordinary mathematician will be enabled, by the help of this treatise and suitable tables, to reduce any class of observations which will be found in their annual volumes, or to examine the accuracy of any individual result. In 1852 Mr. Main compiled for Weale's *London* a most interesting descriptive account of the public and private Observatories in the metropolis and its vicinity, and of those of Oxford and Cambridge.[1] He also revised the article *Astronomy* in the eighth edition of the *Encyclopædia Britannica*, and was the author of the supplement giving an account of the progress in the science since the publication of the previous edition. In 1859 Mr. Main was requested by the Admiralty to undertake the superintendence of the third edition of their *Manual of Scientific Enquiry*.

[1] The instruments in the following Observatories have been described by Mr. Main in this little work:—Greenwich, Kew, Cambridge, the Radcliffe Observatory at Oxford, and the private Observatories of Sir James South, at Kensington; Mr. Bishop, in the Regent's Park; Mr. Simms, at Carshalton; Mr. A. K. Barclay, at Bury Hill, Dorking; Mr. S. C. Whitbread, at Cardington, near Bedford; Dr. Lee, at Hartwell, near Aylesbury; Mr. Snow, at Ashurst, Kent; the Rev. W. R. Dawes, at Wateringbury, Kent; and others less noted. Most excellent astronomical work has been done at these private Observatories, all of which are now closed. Mr. Main's notes on their internal arrangements have, therefore, an historical interest.

This important work, prepared for the use of Officers in Her Majesty's Navy, and travellers in general, was originally edited by Sir John Herschel. In the new edition Mr. Main made an alteration in the arrangement of the articles, particularly in the classification, which was found to be advantageous; and to the article on *Astronomy* by Sir G. B. Airy, he has added some notes on comet observations made with the sextant; on observations made at sea, of occultations of stars by the Moon, and of eclipses of *Jupiter's* satellites; and on the determination of latitude and longitude on shore. Some of Mr. Main's addresses on science and education, written for delivery on special occasions, as at school meetings, the Victoria Institute, &c., are excellent examples of his power of literary composition; and his sermons, though he was not a popular preacher, were generally considered to be well-prepared essays. Mr. Main had a great partiality for church duty, and during his residence at Greenwich he afforded considerable assistance to the local clergy, who ever found him ready when help was required. Before taking up his appointment at Oxford, he published a volume of selected sermons, preached in St. Mary's Church, Greenwich.

Mr. Main had a long connection with the Royal Astronomical Society. His Fellowship dates from March 11, 1836. In the following February he was placed on the Council, and from February 1841 to February 1846 he served as one of the Honorary Secretaries, his colleagues being successively Lieutenant Raper, Mr. Rothman, Mr. Galloway, F.R.S., and Mr. Rutherford. Few at the present time are aware

of the amount of personal interest Mr. Main took in the affairs of the Society till his removal to Oxford, or of the numerous anonymous contributions from his pen, which enriched the Annual Reports of the Council for more than twenty years. From February 1859 to February 1861 he filled the office of President with honour to himself and to the Society. Though his attendances at the Council meetings were only occasional during later years, he made it a duty to join in its deliberations when any subject of more than ordinary importance was being discussed, and he rarely failed to attend the December meeting, when the choice of the Medallist was to be made. To the regret of his friends he retired from the Council in February 1876, after an uninterrupted service, either as Councillor, Secretary, Vice-President, or President, for the long period of thirty-nine years. For his numerous contributions to the Society, most of which we have noticed, he was in 1858 awarded the Gold Medal.

Mr. Main's health broke down rather suddenly. His scientific friends heard for the first time of his illness only a few weeks before his death. His love of work, however, remained to the last, and he could not refrain from assisting in the computations so long as his strength permitted. He had nearly completed his seventieth year at the time of his death, which occurred on May 9, 1878. He has left a widow, sister of Professor Kelland, F.R.S., of Edinburgh; and three sons, the second of whom, Philip T. Main, M.A., Fellow of St. John's College, Cambridge, is the author of an elementary treatise on Astronomy.

CLAUDE L. M. MATHIEU.

1783–1875.

CLAUDE LOUIS MATHIEU was born at Macon, Saône-et-Loire, on November 25, 1783, in humble circumstances. His father, a joiner by trade, intended his son to follow his own occupation; but desiring to make young Mathieu a superior workman, he sent him to an elementary school in his native town, where he received the rudiments of his education, and where he was able to attend a gratuitous course of instruction in drawing. He was soon noted for his aptitude and general assiduity in his studies; and it was here that he first acquired a taste for the study of mathematics. Though without the guidance of a teacher, he soon made himself acquainted with the elementary subjects; but, finding himself frequently in the presence of serious difficulties, he solicited the advice of the learned and venerable Abbé Sigorgne, who became much interested in the young student. The difficulties appeared to be great, but not insurmountable, and he was encouraged by reading daily in the preface of Lacroix's 'Algebra' the precept of D'Alembert:—'Allez en avant, et la fin vous viendra.' Having heard of the École Polytechnique, all his efforts were now directed to obtain admission as a student in that celebrated training-school. He left

Macon in 1801 for this purpose, and arrived in Paris almost without resources. He endured many personal privations during his first two years' residence in the French metropolis, and he was glad to accept the generous offer of a lodging in a small room under the private Observatory of M. Delambre while he was attending a gratuitous course of study at the 'École centrale des quatre nations,' where he eventually gained the first prize for mathematics. In 1803 he had the great pleasure of being admitted a pupil at the École Polytechnique, where he remained two years, leaving it in 1805 with the title of 'Élève ingénieur des ponts et chaussées,' at the age of twenty-two.

In 1806, five years after leaving his native town, through an acquaintance formed with M. Arago at the École Polytechnique, M. Mathieu was appointed to the temporary charge of the Paris Observatory during the absence of his friend in Spain, where he was engaged with M. Biot on an expedition for the continuation of the observed arc of meridian as far as the Balearic Islands. In 1808 Mathieu himself was associated with M. Biot while making a series of pendulum observations at different stations on the Paris meridian, for which he obtained in 1809, and again in 1812, the astronomical prize founded by Lalande. In 1807 he received the appointment of Secretary to the Paris Observatory.

M. Mathieu was elected in 1817 a member of the Académie des Sciences, succeeding Messier in the section of Astronomy, and at the same time he was appointed a member of the Bureau des Longitudes. Subsequently he became a teacher of geodesy, &c.,

at the École Polytechnique; in 1829, professor of analysis; and finally, examiner *de sortie* in the same school, where he is still honourably remembered as a clear, methodical, and conscientious professor.

During M. Mathieu's connection with the Paris Observatory, so much of his time as could be spared from his political duties was devoted to various subjects of astronomical investigation, independently of his usual Observatory work. They include his observations and researches on the figure of the Earth; on refraction; on the obliquity of the ecliptic; on the parallax of the fixed stars, &c. Some of the results of his researches are inserted in the volumes of the *Annuaire*. During this time he resided at the Observatory, in which, as the brother-in-law of Arago, he had a most influential position. On the accession of M. Le Verrier in the spring of 1854, Mathieu's connection with the Observatory ceased, in common with his principal colleagues. Though Mathieu had devoted so large a portion of his life to astronomical pursuits, and at his advanced age might reasonably have taken that opportunity of claiming an honourable retirement, he preferred, after his removal from the Observatory, to be officially employed on the preparation of the *Annuaire* and *Connaissance des Temps*, the publication of which was placed under the control of the Bureau des Longitudes. Latterly, however, his duties were confined chiefly to the superintendence of the *Annuaire*; and it is to him that we have been indebted for those portions relating to astronomy, the physics of the globe, and statistics, the value of which for reference has been so highly

appreciated even out of France. M. Mathieu continued his supervision of this work to the last; and it was only a few weeks before his death, with a failing hand, that he examined the concluding proof-sheets of a new volume of the *Annuaire*, which had been so many years the principal object of his solicitude.

On the death of Delambre, in 1822, a most important part of his *l'Histoire de l'Astronomie au XVIII^e siècle* was left unfinished. This distinguished astronomer left the completion and publication of the work as a legacy to Mathieu; and, in consequence, it appeared in 1827, enriched by him with an historical preface, a large number of important notes, and a very exhaustive analytical table of contents.

M. Mathieu served on several important Commissions. Among those relating to science may be mentioned the joint French and English Commission appointed to make a geodetical connection between the English and French coasts by means of a series of triangles carried across the English Channel; the Lighthouse Commission, of which he was one of the leading members; and the Metric Commission. In 1867 he was chosen President of the International Coinage Commission—an honour repeated in 1872, when he was the President of the International Metric Commission. He also served on the jury at the London International Exhibitions of 1851 and 1862, and at the Paris International Exhibition of 1855. In 1829 he was made a Chevalier, in 1855 an Officer, and in 1863 a Commander of the Legion of Honour. He was elected an Associate of the Royal Astronomical Society on May 12, 1848.

Following the example of his colleague and relative, M. Arago, Mathieu during the period of his middle life divided his time between science and politics, probably to the disadvantage of the former. It is not necessary, however, in this place to enter into much detail respecting his political career. It will be sufficient to remark that he represented his native town in the Chamber of Deputies, without interruption, from 1835 to 1848. After the Revolution of February 1848 the Department of Saône-et-Loire elected him to the Constituent Assembly by 127,052 votes out of 132,000. In 1849 he retired from the Assembly, preferring to devote his remaining time and energy to the service of the Observatory and general science; but he nevertheless retained a great interest in political events to the last. During the siege and the more terrible scenes of the last days of the Commune, he expressed no desire to leave Paris, and his example encouraged his friends around him during this trying time.

M. Mathieu married the sister of M. Arago, and we have already noticed that the subsequent careers of the two astronomers were very much in common, both following the same tastes in science and politics. His daughter became the wife of M. Laugier, his constant companion and friend. The patriarchal age to which M. Mathieu reached shows that he had a strong and healthy constitution, which only succumbed at last to a gradual decay of nature. His death occurred in the first week of March 1875, in the ninety-third year of his age; and at his funeral, on March 8, discourses were pronounced over his grave

by his friends MM. Faye, Loewy, Resal, and Guillemaut.

While the author was residing in Paris in 1854 and 1855, on official business, he had the opportunity of associating with the principal French astronomers, of whom he has retained many pleasing reminiscences; but especially he was much impressed with the urbanity and kindness of his friends, Delaunay, Laugier, and Mathieu, who resided in the same house in the Rue Notre Dame des Champs, all of whom were ever ready to assist him by their counsel, and in other ways. It is somewhat remarkable that within a space of three years it became his melancholy duty to record officially, in the obituary section of the Annual Reports of the Council of the Royal Astronomical Society, an epitome of the eminent services of each of these three distinguished Associates.

The published works of M. Mathieu are not numerous. In addition to his reports on scientific subjects and other papers alluded to in this notice, the following memoirs have appeared in the Appendices to the *Connaissance des Temps*:—

1. *Sur les expériences du Pendule, faites par les navigateurs Espagnols en différents points du globe.* 1816.

2. *Résultats des expériences faites avec des Pendules de comparaison aux îles Malouines et à la Nouvelle Hollande.* 1826.

3. *Rapport sur un mémoire de M. Puissant sur la détermination de la figure de la terre par les mesures géodésiques et astronomiques.* 1829.

4. *Note relative au mémoire de M. Bessel, et aux catalogues des* 36 *étoiles fondamentales.* 1829.

CAPTAIN M. F. MAURY, U.S.N.

1806–1873.

MATTHEW FONTAINE MAURY, the distinguished hydrographer, was born in Spottsylvania County, Virginia, on January 14, 1806. He was of French extraction. At an early age his parents removed into the neighbouring State of Tennessee, where young Maury received his education, but he always retained a deep attachment for his native State. At the age of sixteen he obtained a commission in the United States navy as midshipman on board the 'Brandywine;' and in 1825 he was appointed to the 'Vincennes' sloop-of-war, which had been commissioned for a four years' voyage, intended to include the circumnavigation of the globe. He had thus, in his early life, many opportunities for carrying out his inclinations for scientific observation in different climes and regions, and to enter upon the practical study of ocean meteorology, in which he became, in his maturer years, so experienced an authority. It was in his leisure time during this long voyage that he commenced the preparation of his *Treatise on Navigation*, which has since become very popular in America, and has been adopted by the naval authorities as the principal text-book on that subject for students entering the United States navy. After the return of

the 'Vincennes,' Maury served for a short time as 'master' of the 'Falmouth,' stationed in the Pacific. From this ship he was promoted to a lieutenancy on board the frigate 'Potomac,' where his great knowledge of seamanship and his great scientific acquirements obtained such notice that he was selected in 1836 to accompany Captain Jones, a scientific officer in the United States navy, on an exploring expedition as the superintendent of the astronomical department. Owing, however, to some unforeseen circumstances, neither Lieutenant Maury nor Captain Jones sailed in the expedition, both having sent in their resignations before its departure. In 1839, owing to an unfortunate accident, believed to have been a fall from a coach, which resulted in lameness, Lieutenant Maury was compelled to retire from active naval service afloat. The effects of the accident were very serious, and for some time it was feared that the valuable services of this enterprising scientific officer would be permanently lost to his country. The American Government, however, found for him a congenial office by placing him in charge of the depository of naval charts and instruments at Washington. Here his active habits soon succeeded in reorganising the entire arrangement and business of the establishment, transforming it, in fact, into the nucleus of the present astronomical Observatory. It had been the intention of the Naval Department of the Government for some years previously to establish a first-class Observatory at Washington, and the main part of the present building had already been erected under the superintendence of Lieutenant

Gilliss in 1844, before the appointment of Lieutenant Maury as its director, or superintendent, which dates from October 1, 1844. The Naval Observatory is situated on the north bank of the Potomac, in the south-western section of the city, and several additions have been made to it since its erection, both by Maury and his successors.

Lieutenant Maury had, from the time of his entry into the naval service, a great talent for discussing meteorological observations, and particularly of those made at sea, relating to the direction and velocity of the winds and oceanic currents; and during most of his cruises he made it his frequent occupation to carry out several series of observations, under various circumstances, in order to form a theory of ocean meteorology, with the object of turning it to practical account for the benefit of mariners. When he became the directing officer at the depository of charts and instruments, or more properly the Hydrographic Office, he naturally used his great influence among naval men to recommend the regular observation at sea of the direction of the wind and of ocean currents, as well as other meteorological observations; and to enter at the time all notes in the log-book, so that they might be available for a subsequent examination at the Observatory. The plan drawn up by Lieutenant Maury in 1842, and generally adopted in the service, included the registration of the direction and force of the wind every eight hours; the direction, velocity, depths, and limits of the various currents; the temperature of the air, of the water on the surface and at various depths, besides other phenomena

bearing on the subject of ocean meteorology. In this manner a valuable collection of data was obtained, with the advantage that all the observations were made on one uniform system. The scheme answered so well, that in eight or nine years a sufficient number of observations had accumulated to fill 200 manuscript volumes, each averaging about 2,500 days' observations. It was understood throughout the service that it was the duty of the master of every vessel, on returning from a voyage, to deposit the 'abstract log' at the Naval Observatory. The pith of this mass of records formed the material upon which Lieutenant Maury's celebrated work on the *Physical Geography of the Sea* was founded.

In this remarkable work Lieutenant Maury gives a popular *résumé* of all his investigations relating to ocean meteorology. In the introduction his remarks on the contents of the work explain, in a few words, the object he had in view in presenting the book to the public. 'Under the term "Physical Geography of the Sea," will be included a philosophical account of the winds and currents of the sea; of the circulation of the atmosphere and ocean; of the temperature and depth of the sea; of the wonders that lie hidden in its depths, and of the phenomena that display themselves at its surface. In short, I shall treat of the economy of the sea and its adaptations; of its salts, its waters, its climates, and its inhabitants; and of whatever there may be of general interest in its commercial uses or industrial pursuits.' This work first appeared in 1855, and it gave an extraordinary stimulus to the study of ocean meteorology;

but its great success did not arise altogether from the various theories contained in it—some of which have been objected to, especially that in explanation of the cause of the Gulf Stream—but in a great measure its popularity was owing to the interesting manner with which the driest of meteorological details are arranged and discussed. The work has not only been republished in several editions in England, but it has also been translated into all the principal European languages. Adopting the words of a recent writer: 'His unrivalled powers of application and untiring perseverance were combined with rare gifts of imagination, and an almost poetic style. Hence he not only collected materials with judicious discrimination, and arranged them with critical skill, but also combined them so as to produce one of the most fascinating books in the English language.'

In 1853 Lieutenant Maury represented the United States at the Maritime Conference held at Brussels in that year, for devising a uniform system of meteorological observations at sea. Most of the maritime nations of Europe were also represented at this Conference, including England, France, Russia, Belgium, Holland, Portugal, Denmark, and Norway and Sweden. This international scientific meeting was brought about principally through the exertions of Maury, who was one of its leading members, his advice and labours calling forth from his colleagues an expression of thanks for the enlightened zeal and earnestness he had displayed in the important and useful work which formed the subject of their deliberations. One of the principal results of the Con-

ference was the establishment in 1855 of the Meteorological Department of the Board of Trade, which was placed under the direction of the late Admiral Fitzroy. Lieutenant Maury was shortly afterwards promoted to the rank of commander in the United States navy.

When, in 1861, the outbreak of civil war between the Northern and Southern States of America occurred, Captain Maury, like many other high-minded Virginians, threw up his commission in the navy of the United States, choosing rather to be considered a rebel than to fight against his kinsmen and friends. No one can doubt that his sacrifice even of professional advancement was great, but the loss to science was greater, by this sudden resignation of his position at the Naval Observatory. But Maury was a Southerner by birth, and his national feeling of honour would not allow him to remain in the service of a Government whom he considered to be the determined enemies of those most dear to him. Hence, on April 19, 1861, he threw in his lot with the Confederate States of the South, the leaders of which he assisted in various ways, especially by his counsel in the construction of the maritime defences, which enabled the Confederates to hold their own so long. During the war his house was destroyed, together with a valuable collection of manuscripts and books; his scientific instruments were confiscated, and he came to Europe on a visit as an impoverished exile. He was received by his European friends with great kindness and respect; and at a banquet given in his honour a valuable testimonial, consisting of a purse containing upwards of 3,000 guineas, was presented

to him by Sir J. S. Pakington (now Lord Hampton), in the name of his sympathising friends of all nations. While he was in Europe many attempts were made by more than one Government to attach him to their service; but he remained faithful to his own State till the final overthrow of the South, when he joined the fortunes of the Emperor Maximilian, in Mexico, who appointed him Imperial Commissioner of Emigration. He remained in this office till the fall of Maximilian, when he retired to Virginia, taking the position of a Professor at the College at Lexington. During the last few years of his active life Maury, though in frequent ill-health, exhibited the same devotion and energy in all that he undertook as in his earlier days. One of his latest propositions was the organisation of a system of combined meteorological reports on land for the benefit of farmers as well as of sailors. He was very desirous that his fellow-citizens should discard political animosity, and devote themselves to the development of the agricultural and other resources of their country. Thus he remained to the end of life the friend of science and his fellow-man, and he has passed away leaving many warm and attached friends on both sides of the Atlantic. Captain Maury died at Lexington, on February 1, 1873, having a few weeks before completed his sixty-seventh year. He was elected an Associate of the Royal Astronomical Society on January 12, 1855.

REV. ROBERT MIDDLEMIST.

1808–1877.

THE REV. ROBERT MIDDLEMIST, M.A., was born on February 29, 1808, and was descended from a respectable Northumberland family. He was educated principally by his relative, Mr. Gourley, who was at that time Head Master of the Grammar Schools at Morpeth and Hexham. When quite a youth, he was in the habit of answering mathematical questions given in the *Lady's Diary*, by which means he soon became known by name to some of the leading mathematicians of the day, who were also contributors to the mathematical section of the *Diary*. By one of these, but an entire stranger to him, he was recommended, in 1831, to Lieutenant W. S. Stratford, F.R.S., the Superintendent of the *Nautical Almanac*, as a highly qualified computer and a good mathematician. This led to his engagement as one of several young computers, mostly from the north of England, for the new *Nautical Almanac* Office in London, then in course of organisation by Lieutenant Stratford, in conformity with the resolution of the Council of the Royal Astronomical Society, passed in November 1830, recommending a totally new arrangement of the contents of the *Nautical Almanac*, according to the demands of the advanced state of astronomy.

These recommendations, drawn up by a Committee of the Society, were approved in detail by the Lords Commissioners of the Admiralty, and ordered by them to be carried into effect. The old edition of the *Nautical Almanac*, down to the volume for 1833, had retained nearly the same form as that of the original Almanac for 1767, as arranged by Dr. Maskelyne, the Astronomer Royal. Until the establishment of the new office, it was the custom to employ computers residing in different parts of the country, and, during the later years of the old series, these may have been found located in counties separated from each other by hundreds of miles. In the year 1828, three of the computers had their homes in Cornwall, others at Arbroath, N.B., Ludlow, and London or Greenwich; the comparer, to whom all the computations were sent for examination, resided at Tideswell; while the Superintendent, Dr. Thomas Young, F.R.S., controlled the whole from his house in London, and this in the days of mail coaches and expensive postage. On the establishment of the London office, most of the old computers retired; but Mr. W. Dunkin,[1] of Truro, and Mr. H. Jenkins, of Greenwich, were retained for further service.

[1] Mr. William Dunkin's first connection with the *Nautical Almanac* dates from near the beginning of the century, when he acted as assistant to the Rev. Malachy Hitchins, Vicar of St. Hilary, near Marazion, Cornwall, who is known in astronomical history as an observer of the transit of *Venus* at the Royal Observatory in 1769. Dr. Nevil Maskelyne, F.R.S., Astronomer Royal, in giving an account of the Greenwich observations of the transit (*Phil. Trans.*, vol. lviii. p. 360) refers to Mr. Hitchins as 'a gentleman well acquainted with astronomy and astronomical calculations, who has made and examined many belonging to the *Nautical Almanac*, and has been so obliging as to come here

Mr. Middlemist was one of the first of the new computers appointed by Lieutenant Stratford, and he was therefore engaged on the computations of the first volume of the new series. He was much trusted by the Superintendent, who had great confidence in his abilities, and he was selected to make the necessary careful comparison and examination of the duplicate calculations; a duty he performed with such patience and fidelity, that Lieutenant Stratford remarked, in the Preface of the *Nautical Almanac* for 1834, that it was impossible to appreciate too highly the manner with which he executed this most tedious but important task. Mr. Middlemist joined the Royal Astronomical Society on March 14, 1834.

After having served for some time as mathematical master in the Royal Naval School, Mr. Middlemist entered Christ's College, Cambridge, in 1838, as an undergraduate. He became a scholar of his college, and graduated as B.A. in January 1842, being 27th Wrangler. For a time he acted as curate to the Rev. J. E. Gretton, of Stamford; but in 1845 he received the appointment of senior assistant

and assist me in making astronomical observations during the absence of my assistant, Mr. William Bayley, who is gone to the North Cape, by appointment of the Royal Society, to observe the transit of *Venus* there.' Mr. Hitchins, who was the comparer of the *Nautical Almanac*, died in 1809, before which, however, Mr. Dunkin was appointed permanently as one of the computers. About the year 1814 Mr. Dunkin removed to Truro, where he continued to reside, having charge of so much of the *Almanac* each year as related to the five months, May to September. Through the interest and recommendation of his old friend, Mr. Davies Gilbert, M.P., F.R.S., he joined the London office in June, 1832, to which he remained attached till his death on July 3, 1838, at the age of fifty-seven.

mathematical master in Harrow School, an office which he retained till his death. He was also vicar of Little Linford, Bucks. Though an occasional attendant at the meetings of the Royal Astronomical Society, Mr. Middlemist does not appear of late years to have interested himself much in astronomy, and he has never been a contributor to the *Monthly Notices* of the Society. While on a visit to his sister at Ramsgate, he was suddenly attacked with inflammation of the lungs, and died there eight days afterwards, on January 11, 1877, in the sixty-ninth year of his age. He has left a widow and seven children—six sons and one daughter.

Sir RODERICK MURCHISON, Bart., K.C.B., F.R.S.

1792-1871.

SIR RODERICK IMPEY MURCHISON, Bart., K.C.B., was born on February 19, 1792, at Tarradale, a small estate in the possession of his father, in eastern Ross-shire, N.B. He was the eldest son of Mr. Kenneth Murchison, and of Barbara, daughter of the late Mr. Kenneth Mackenzie, of Fairburn, in the same county. At a very early age he left Scotland for Dorsetshire, and, excepting a short period when he resided with his mother in Edinburgh, his boyhood was principally spent in England, where he received his education. He was first placed in the grammar-school attached to the Cathedral of Durham; but, exhibiting a strong inclination for the military profession, he was removed to the Royal Military College at Great Marlow. He subsequently attended, for a few months only, the classes at the Edinburgh University; but his studies were interrupted by receiving, in 1807, a commission in the army, he at the time being just fifteen years of age. In 1808 he joined the British forces in the Peninsula, under Sir Arthur Wellesley, as ensign in the 36th Regiment of Foot; and afterwards he served either on the staff of his uncle, Sir Alexander Mackenzie, or as Captain in the 6th Dragoons. He

shared the varied fortunes of the division of the army to which he was attached, having fought in three general actions, Roliça, Vimiera—where he carried the colours of his regiment—and Corunna, including all the hardships and dangers attending the memorable retreat under Sir John Moore. Returning to England, Captain Murchison married, in 1815, Charlotte, only daughter of the late General Francis Hugonin, and thus concluded, as he was frequently heard to remark, the military episode of his life.

Murchison was, however, of far too active a disposition to remain in a state of idleness at the age of twenty-three: so, in the absence of better employment, the exuberance of his spirits found vent in the excitement of the chase. Fox-hunting became one of his chief pastimes, and he entered into its pleasures with all the energy at his command. He might have continued a popular, sporting, country gentleman, but for the influence of Mrs. Murchison, a lady possessing a considerable knowledge of conchology and a fondness for natural history pursuits. Through her he received his first encouragements to pursue the study of geological science. It happened, also, that about this time he accidentally met Sir Humphry Davy, F.R.S., at the house of Mr. Morritt of Rokeby. Sir Humphry, seeing too much practical sense in young Murchison for a mere fox-hunter, advised him to attend the lectures on physical science at the Royal Institution. He not only attended the lectures, but he followed them up by a series of practical experiments on his own account. To do this in a satisfactory manner, he placed himself under the private instruction of Mr.

Richard Phillips, F.R.S., from whom he received every encouragement to sketch out for himself a scheme of original investigation, which led in after years to his successful researches in the branch of science to which he more particularly devoted his attention. It is from this date that the career of Roderick Murchison as a geologist may be said to have commenced.

His first paper was presented to the Geological Society in 1825, entitled *A Geological Sketch of the North-western Extremity of Sussex, and the adjacent Parts of Hampshire and Surrey.* It is published in vol. ii. of the *Transactions* of that Society. Murchison was now thirty-three years old, and henceforth he devoted his whole energies to the practical study of his adopted science. Year after year we find him occupied in the personal examination of the geological formations of various districts in Great Britain and on the Continent, beginning in 1826 with the coal strata in Sutherlandshire, which he demonstrated to be a branch of the Oolite series. In 1827 he again visited the Highlands in company with Professor Adam Sedgwick, F.R.S., of Cambridge, when they succeeded in proving that the primary sandstone of M'Culloch was really nothing more than the true old red sandstone, now also called 'Devonian.' In the following year, accompanied by Mr. (afterwards Sir Charles) Lyell, F.R.S., he examined the volcanic rocks of Auvergne and the tertiary strata of Southern France. In this manner, first in one country and then in another, he continued his observations in the field, adding fact upon fact, all of which are recorded

in the *Transactions* of the Geological Society and in other scientific publications. In the catalogue of scientific papers to 1863, published by the Royal Society, Sir Roderick Murchison is credited with 111 separate papers, and twenty-six published in conjunction with other authors. To all the labour required in the preparation of such a mass of work must be added that necessarily involved in the writing of the valuable treatises, published separately—*The Silurian System*—*On the Geology of Russia*—and the successive editions of *Siluria*. The last named is perhaps the best known of his writings, and, more than any other of his works, has helped to lay the foundation of Sir Roderick's fame. It is entitled *Siluria; or, the History of the oldest known Rocks containing organic Remains, with a brief Sketch of the Distribution of Gold over the Earth;* and includes a general view of the structure of the Earth's crust, but more particularly of the more ancient series of strata, of which the Silurian system is the lowest; it also includes a summary of the author's opinions with respect to geological science, especially on those matters where he differed from his distinguished friends, Professor Sedgwick and Sir Charles Lyell.

As a geographer, Sir Roderick Murchison stood in the foremost rank. The great influence he held over the proceedings of the Royal Geographical Society could be perceived in a moment by the most casual visitor to its ordinary meetings. No one took a greater interest in the progress of physical geography than he did, down to the last few days preceding his death. His annual addresses at the anniversary

meetings of the Society always contained an excellent epitome of geographical discovery during the year. His kind and courteous manners, coupled with the zeal and energy with which, as President, he supported the cause and personal well-being of travellers, both before and after their journeys, made him at once their trusted counsellor and friend. His name is thus known to all the civilised world as the chivalrous defender of such men as Dr. Livingstone, Captain Speke, M. Du Chaillu, and others, against the apparently adverse criticisms of some of their fellow-geographers.

With the attention of Sir Roderick so engrossed in geological and geographical pursuits, he still found time to interest himself in some of the recent great discoveries of observational astronomy, especially of those relating to the physical constitution of the solar photosphere and corona. He, however, never took any active part in the promotion of astronomical research, for he wisely left to others, more qualified than himself, the practical part of our science. But in one important branch he has done good service. He took every opportunity of impressing upon travellers the advantages to be derived from the frequent determinations of the absolute longitudes and latitudes in unexplored regions by astronomical observations. He was therefore always desirous that travellers, before leaving England, should receive instruction from properly qualified observers, so that they might become acquainted with the practical use of the sextant and other portable instruments. Through his recommendation, also, the accumulated observations of

lunar distances, meridional altitudes, temperatures of the boiling point of water, &c., made by Captain Speke, Mr. Petherick, M. Du Chaillu, and other African travellers, were wisely placed under the care of an official astronomer, in order that they might be reduced by the use of the most approved astronomical methods. In this manner the geographical positions of several important points in the interior of Africa have been very satisfactorily determined, the details of which are inserted in the *Journal* of the Royal Geographical Society, vols. xxxiii. to xxxvi. Sir Roderick also showed his interest in the Royal Astronomical Society, and in astronomy, by becoming a Fellow in 1850.

On the death of Sir Henry De la Beche, F.R.S., in 1855, Sir Roderick Murchison was chosen to succeed that eminent geologist as Director of the Museum of Practical Geology in Jermyn Street, and as Director-General of the Geological Survey of England, an official position which he retained till his death. It is scarcely necessary in this brief notice to enumerate more than a selection of the honours, royal and academic, which have been conferred on Sir Roderick in recognition of his scientific labours. By his own sovereign he was created a Knight Bachelor in 1846, a K.C.B. in 1863, and, finally, a Baronet in 1866. He also received numerous foreign orders of distinction, including the Grand Cross of St. Anne, and of St. Stanislaus of Russia, and the dignity of Grand Officer of the Order of the Crown of Italy. The Universities of Oxford, Cambridge, and Dublin recognised his researches in geology by the bestowal

on him of their honorary degrees. In 1826 he was chosen a Fellow of the Royal Society, and subsequently became a member of the Council and a Vice-President. He was one of the founders of the Royal Geographical Society, and was first elected its President in 1843. He was re-elected at intervals up to 1862, since which year, till May 1871, he, by the general consent of the Society, remained in office. He also served as Secretary and President of the Geological Society. In addition to the numerous English and Foreign Societies of which he was an honorary member, Sir Roderick was also a Trustee of the British Museum, the Hunterian Museum, and of the British Association for the Advancement of Science. He received the Copley Medal from the Royal Society, the Prix Cuvier from the French Institute, the Brisbane Medal from the Royal Society of Edinburgh, the Wollaston Medal, and other honours of the same kind.

In 1869, Sir Roderick sustained a great loss by the death of Lady Murchison, his companion of more than half a century. The first visible sign of his own decay manifested itself in an attack of paralysis in the latter part of 1870. He was in a dangerous condition for some time, and he remained afterwards in a more or less delicate state of health. However, he was able occasionally to appear in public; but he was never thoroughly himself again, and was obliged to delegate to others the duty of Chairman at the meetings of the Royal Geographical Society. Two months before his death he was seized with loss of speech, accompanied with difficulty in swallowing. These

unfavourable symptoms gradually subsided, and his general health appeared to be restored to its usual state. But on Thursday, October 19, he caught a cold during a drive, which subsequently resolved itself into bronchitis. His constitution was not sufficiently strong to withstand this sudden attack, and he quietly sank under its influence. He passed peacefully away on the evening of Sunday, October 22, 1871, in the eightieth year of his age.

'Such has been the praiseworthy life of this illustrious man,' remarks a writer in the *Athenæum*; 'and while his fellow-countrymen have long since pointed out with pride to the stranger the house where Murchison was born, there are mountains and rivers in distant lands which shall tell out his fame to future ages in tones far louder than could ever re-echo from the vaults of Westminster Abbey.'

FRANK ROBERTSON.

1838–1873.

FRANK ROBERTSON, late First Lieutenant Royal Madras Engineers, was born in London in the year 1838. He was the youngest and last surviving son of the late Robert Robertson, Esq., of Auchleeks, Perthshire. In 1854 he commenced his professional studies at Addiscombe, where he soon became one of the most successful students of the College, especially in chemistry, the prize for which he gained in his first term, an honour which till then had been considered as belonging exclusively to the senior students. After practically studying his profession at Chatham, he was appointed in 1859 to the Madras Engineers; and on his arrival in India he was placed in charge of many important works; but in consequence of a severe illness, produced by an incautious exposure to the Sun at Nagpore during the performance of his duties, he returned to England in the winter of 1861 in a very weak condition. Before his illness he superintended the construction of several military buildings to the satisfaction of his commanding officer, and doubtless would have further distinguished himself in his corps; but owing to some difficulty in his obtaining a medical certificate without considerable delay, which his dangerous state of health would not

permit, he sacrificed his position in the army by resigning his commission before leaving India.

Lieutenant Robertson had a great natural taste for civil engineering, both in theory and in practice, and on his recovery he returned to India as a civil engineer; but his health again soon broke down, and he was once more driven home. His devotion to his profession was, however, so great that a third time he proceeded to India, where his reputation as a practical engineer soon found him employment under the Department of Public Works, latterly at Murree, under the direction of Colonel Maclagan. In this capacity his talents were duly appreciated by the Government, and it was hoped that he would become permanently attached to the service; but his health, which had never been perfectly restored since his first illness, compelled him, after a time, again to retire, and to seek the more bracing climate of Europe. During the period of the Franco-German war, Mr. Robertson, then residing at Darmstadt, joined a number of young men, who devoted themselves to the care of the sick and wounded soldiers who had been brought there from the various divisions of the army. Heartily sympathising with their misfortunes, and being partly an invalid himself, he gave what strength he had to alleviate their sorrows. His humane services were thankfully appreciated by these poor men, especially by those whose weakness prevented them from waiting on themselves.

At the end of 1872 Mr. Robertson's health had so far been restored, that he, for the fourth time, looked to India as the field for his future exertions. He

even thought that he was now sufficiently strong to brave the hot climate, which, on so many previous occasions, had always proved his greatest enemy. In January 1873 he therefore left England for India, and again found employment in the Public Works Department. He was attached to the branch of the service then employed in the Punjaub, and the construction of some very important engineering works was placed under his special care; among them a bridge of boats was prepared and maintained by him at a very critical time, when the railway bridge over the river Sutlej had given way, and when the other bridges of boats in the same locality had all been carried away by the floods. An extract from a characteristic letter written by Mr. Robertson to his sister, dated Phillour, June 4, 1873, exhibits his devotion to his work at a time when the strain on his mind was very severe: 'I am so glad about the bridge. The Punjaub Government say it is the most important work in the whole division, and no doubt it is so; they have done their utmost to urge me to hold on till the railway bridge could be restored, and now it is all finished and all right. The other bridges are for mere road communication over the Jhelum, Ravichenab, Beas, &c., and all have given way weeks ago; mine alone bears the railway traffic, and each day it has been kept open the Government has gained £200 sterling.' A few months afterwards he suffered from an acute attack of dysentery, and was advised for the last time to return to Europe immediately. He left Bombay about the middle of September, and died on board the Peninsular and Oriental steamship 'Tanjore,' near Aden, on Sep-

tember 27, 1873, at the early age of thirty-five, only ten months after he had left England.

In 1871 Mr. Robertson published a most valuable series of tables for facilitating the construction of arches, which has been found to be of great practical use to civil engineers. He was elected a Fellow of the Royal Astronomical Society on February 11, 1859.

WILLIAM RUTHERFORD, LL.D.

1798–1871.

WILLIAM RUTHERFORD, LL.D., was born in the year 1798. In early life he exhibited a great desire to study mathematics; in which he soon became more than usually proficient in the higher branches. This ultimately led to his engagement as one of the mathematical masters in the Royal Military Academy at Woolwich, to which institution he remained attached for a considerable number of years till his retirement on superannuation about eight years before his death.

Dr. Rutherford was very popular as an instructor, and his explanations of the difficult points which usually arise in class-teaching were remarkable for their clearness. His ordinary methods of imparting instruction were always of a most practical character, for it was his custom to impress on the cadets the necessity of their treating the study of mathematics as a means for their advancement in professional knowledge, rather than looking at it merely as a subject of mental training. Thus all his scientific teaching was of a most practical character, and his mathematical questions at the examinations of the cadets generally consisted of problems likely to occur to officers of the scientific branches of the army on active service. He was of a quiet disposition, but he took

great interest in the progress of the cadets in mathematical knowledge, and when any one desired assistance he was ever ready to give him the benefit of his experience.

When the *Lady and Gentleman's Diary* was a favourite medium for the publication of mathematical problems and their solutions, contributed by correspondents in various parts of the kingdom, Dr. Rutherford was one of the most regular of the contributors to the mathematical section, both as a proposer and solver of problems, and his successful solutions of some of the most difficult questions gained him considerable notice among the readers of that once popular annual. These proved that he was a mathematician of no mean rank; but he was also well known as the author of several mathematical pamphlets, one of which, on the solution of spherical triangles, is particularly worthy of notice. He delighted in what he was accustomed to call a 'very pretty problem,' or in some question involving a delicate mathematical analysis; and in his later years, when he was relieved from his official duty, nothing pleased him more than to have some question submitted to him for examination, requiring perhaps a week's close attention before a solution was obtained.

Dr. Rutherford joined the Royal Astronomical Society on May 8, 1840, and was a member of the Council from 1844 to 1857. His practical mathematical knowledge was advantageously made use of in many important questions which came before the Society, and between February 1845 and February 1847 he filled the office of Honorary Secretary, his

colleague in the first year being the Rev. R. Main, and in the second year the Rev. R. Sheepshanks. Though Dr. Rutherford was a frequent contributor to mathematical journals, he does not appear to have communicated any original paper to the Society, though he was well versed both in theoretical and practical astronomy. He was, however, always much interested in the scientific investigations of his many friends, and also in the principal researches brought before the Society at the evening meetings for some time after his relinquishment of his seat at the Council.

Dr. Rutherford retired from his Mastership in the Royal Military Academy about the year 1863, after a very long service. He continued in the enjoyment of his usual good health, and was in the habit of taking his daily constitutional walk, till within a few months of his death, which took place at his residence in Maryon Road, Charlton, on September 16, 1871, at the age of seventy-three.

RIGHT HON. SIR EDWARD RYAN, F.R.S.

1793–1875.

THE RIGHT HON. SIR EDWARD RYAN, F.R.S., was born on August 28, 1793. His early education was received at a private school, and in the autumn of 1810 he matriculated at Trinity College, Cambridge, where he was the friend and contemporary of Sir John Herschel, F.R.S., Mr. Babbage, F.R.S., and Dr. Peacock, F.R.S. Graduating as B.A. in 1814, he immediately directed his attention to the study of law, and in 1817 was called to the Bar at Lincoln's Inn, where he pursued his profession for some years with great success. At this time his personal acquaintance with some of his Cambridge scientific contemporaries created in his mind an interest in philosophical pursuits, and particularly in astronomy, although it is not known that he ever attempted any original scientific investigation. His acquaintance with such men as Herschel, Babbage, and other astronomers, led him to join the Royal Astronomical Society soon after its foundation, his election dating so far back as February 1820. Mr. Ryan's success as a lawyer speedily attracted the attention of the Government, and in 1826 he was offered the office of Puisne Judge of the Supreme Court of Calcutta, which he accepted, receiving at the time the honour

of knighthood. In 1833 he was promoted to the Chief Justiceship of the Presidency of Bengal. During his residence in Calcutta his genial nature was much appreciated by the European residents, and his pleasant and hospitable home in Garden Reach was always open to all new arrivals from England, or to welcome the faces of old friends. It has been remarked that 'the genial Chief Justice was the life and soul of society in Calcutta.' Sir Edward retained the office of Chief Justice till January 1843, when he permanently returned to England. Soon after his arrival home he was sworn in a Privy Councillor, so that the country might have the benefit of his experience as a Judge in cases of Indian Appeals to the Judicial Committee of the Privy Council, a duty which he discharged for many years. In 1851 he received the appointment of Assistant-Controller of the Exchequer, which he held till 1862.

The country had the benefit of Sir E. Ryan's services down to the end of his long life, and it may truly be said that he died in harness. When the question of filling the junior offices of the Civil Service by competition, rather than by patronage, was decided by the establishment of the Civil Service Commission, Sir Edward's administrative abilities pointed him out as the most fit person to superintend the experiment, and consequently, by an Order in Council dated May 21, 1855, he was named First Commissioner. The office being an unpaid one, he still retained the Assistant-Controllership of the Exchequer till 1862, in which year the Commission was established on a permanent footing. Under the presidency of Sir E.

Ryan, the duties of the Commission had been gradually increased yearly, the mere test examination having been followed by limited competition, which was soon succeeded by the open competitive examinations as carried on at the present time. During the twenty years that Sir Edward was at the head of this Commission, he was its guiding spirit, giving to it his time and thoughts with a tact and sagacity rarely surpassed in the public service. In addition to his various permanent duties, the Government availed themselves of Sir Edward's advice and experience as a Railway Commissioner, in 1846, and in other matters of public importance. He also took a great interest in the prosperity of the University of London, of which he was a member of the Senate, and for a short period after the death of Mr. Grote, the historian, he served as Vice-Chancellor. He was elected a Fellow of the Royal Society in 1860.

Sir Edward married, in 1814, Louisa, daughter of William Whitmore, Esq., of Dudmaston, Shropshire. His death took place at Dover, where he had just gone for his vacation, on the night of Sunday, August 22, 1875, after an illness of four days, and within a week of completing his eighty-second year. He retained his consciousness and vigour of intellect to the end. His kindly face and stately figure will long be missed, not only by his official colleagues, but also by society generally, in which he has always been much esteemed.

PROFESSOR GIOVANNI SANTINI.

1786-7-1877.

GIOVANNI SANTINI was born on January 30, 1786 or 1787 (both dates have been mentioned), at Caprese, near Borgo di San Sepolcro, in the province of Arezzo, Tuscany. In early life he studied astronomy with Piazzini at Pisa, and afterwards he placed himself under the direction of Oriani, director of the Observatory in the Jesuit College at Milan, and of his assistant, Cesaris. In November 1806 he was appointed an assistant astronomer in the Observatory at Padua, where in a few years he became known as one of the rising young astronomers of the age. So early as 1808 and 1809 we find that Santini was a contributor to the *Monatliche Correspondenz* of Zach; and his papers in that publication, containing observations of a recently discovered comet, and of the minor planets *Ceres* and *Vesta*, gave indications of his future successful career as a practical astronomer.

In 1813, Santini received the appointment of Professor of Astronomy in the University of Padua, and also of Director of the Observatory. While strictly devoting himself to the duties of his professorship, he never neglected those of the Observatory, and he lost no opportunity of observing any newly-discovered

comet, and the first four minor planets, especially of *Vesta*, which he continued to observe regularly at every opposition for more than twenty years after its discovery. During a large portion of his long career, miscellaneous observations of this kind continued to be his favourite occupation, and an examination of the titles of his papers shows that the greater number of his communications to societies, the *Astronomische Nachrichten*, and other serial publications relate chiefly to this branch of equatoreal astronomy.

In 1837 Professor Santini resolved to inaugurate a new system of observations at the Observatory of Padua. In that year an excellent meridian-circle was erected, and with this instrument he was induced to undertake some special meridional work in addition to that which had hitherto occupied his time; but in doing this he determined still to continue occasionally his equatoreal observations. In his ordinary measurements of differences of right ascension and declination between comets or minor planets and neighbouring stars, Santini had often experienced much inconvenience from the difficulty of finding in existing star-catalogues a sufficient number of stars suitable for comparison whose places had been satisfactorily determined. At that time the reduced places of the zone-stars observed by Bessel were not available, nor was there any other catalogue of small stars which could give much assistance to the observer. He therefore considered that his new meridional instrument could not be employed in more useful work than in supplying well-determined places of a selected number of small stars, suitable for comparison with comets,

or of the four then known minor planets. He therefore planned a scheme of zone-observations of stars in right ascension and declination with the new meridian-circle, so that in each parallel of declination, within certain limits north and south of the Equator, there would be found a star, at every eight or ten minutes of time, whose place could be depended upon. Santini commenced his observations early in 1838, and all the observations made from that date to the autumn of 1840 were reduced and incorporated into a catalogue of 1,677 stars, which he communicated to the Royal Astronomical Society in December 1840, under the title of a *Catalogue of* 1,677 *Stars included between the Equator and* 10° of *North Declination, observed at the Royal Observatory of Padua.* It is inserted in vol. xii. of the *Memoirs.* The places derived from this catalogue, the first of a series, were at once recognised as being well determined, and they have been found of great service in comparison-observations of newly-discovered minor planets and comets. This practical confirmation of the desirability of an extended system of observation of the positions of small stars, at a time when there was no reduced catalogue of these objects in the possession of observers, had some influence in encouraging Santini to continue his observations of the other zones on both sides of the equator which formed part of his original scheme. These zone-observations were therefore continued at Padua since 1840 under Santini's direction, either by himself or by his assistants, Trettenero, who died in 1863, and Lorenzoni. Several instalments have appeared from time to time, each catalogue containing the reduced

mean places of a large number of stars, and the complete series forms a very valuable contribution to the libraries of astronomers. Excepting the first catalogue, before alluded to, they were communicated to the Istituto Veneto di Scienze, and published in the *Memoirs* of that Society.

Professor Santini communicated several papers directly to the Royal Astronomical Society, all of which may be found in the *Memoirs* and *Monthly Notices*. They relate principally to observations of the comets of Bremiker, Colla, De Vico, and Biela, and of the planets *Ceres*, *Pallas*, and *Vesta* near their oppositions in 1826; observations of the right ascension of *Venus* about her inferior conjunction in 1830, and miscellaneous notes. In an important paper on the solar eclipse of July 1851, Professor Santini discussed the different observations made in various parts of Europe, from which he deduced corrections to the lunar tables of Burckhardt in longitude and latitude, and to the sum of the semidiameters of the Sun and Moon. By substituting the resulting values of the three corrections in the equations of condition, he found that they satisfactorily represented the residual errors. His papers on the variations in the elliptic elements of the periodical comet of Biela, produced by the action of *Jupiter*, *Saturn*, and the Earth, deserve also a special mention.

Few astronomers have had the opportunity of devoting so many years to the service of astronomy as Santini. The best proof of the activity of his life as an observer is contained in the *Catalogue of Scientific Papers* prepared by the Royal Society. In the

first section of this work, which includes papers published before the end of 1863, we find the titles of 137 separate astronomical papers duly recorded, sixty of which are relating to observations of comets, including, in addition to those already alluded to, the comets of Encke, Halley, Mauvais, Faye, and Petersen; and forty to observations and remarks on the older minor planets. Among his miscellaneous papers are several determinations of latitude, and observations of the solar eclipses of 1820, 1842, and 1851. He was also the author of an excellent treatise on the *Elements of Astronomy*, and of another on the *Theory of Optical Instruments.*

At one period of his life the health of Professor Santini gave great anxiety to his friends, which he himself evidently shared. In 1840, having scarcely completed his first series of zone-observations, he, at the age of fifty-four, wrote of the rapidly declining state of his health, and he expressed doubts whether, at his age, with weak health, he would be able to accomplish the work which he had laid down for himself to do. He knew, however, that his scheme of zone-work, if successfully carried out, must prove useful to astronomers, and that, if his illness continued, others would probably undertake to complete the observations of the remaining zones. His illness and its accompanying anxieties fortunately passed away, and, with the valuable assistance in the Observatory of Signors Trettenero and Lorenzoni, he lived to see the general completion of his original plan of observations and the publication of the reduced mean

places of the stars for the respective epochs of the catalogues.

In early life Santini entered the Church, in which he had priest's orders. This, however, never interfered with his professional work as the Professor of Astronomy in the University, or as the Director of the Observatory. In private life he was universally beloved and respected; and, though he survived to the great age of ninety-one, his death caused a blank among his scientific friends which will be difficult to fill. He died on the morning of June 26, 1877, at his residence at Padua.

Santini was elected an Associate of the Royal Astronomical Society so long ago as March 11, 1825.

PROFESSOR ADAM SEDGWICK, F.R.S.

1785–1873.

PROFESSOR ADAM SEDGWICK, LL.D., F.R.S., was born at Dent, Yorkshire, on March 22, 1785. He entered Trinity College, Cambridge, in 1804, and graduated as B.A. and Fifth Wrangler in 1808, the late Lord Langdale and the late Dr. Blomfield, Bishop of London, being his contemporaries; the former as Senior, and the latter as Third Wrangler. In 1810 he was elected to a Fellowship of his College, which he retained to the time of his death. Mr. Sedgwick at once took an active part in the direction both of his College and University, and he filled at one time the office of Vice-Master of Trinity. He was during one year Proctor of the University; and in this usually unpopular office, though he conducted it with great strictness in all essential points, he adapted himself so well to the feelings of the University students that he was exceedingly popular. His natural fondness for the study of geology, which in those days was scarcely known in England as a science, obtained for him, in 1818, the Woodwardian Professorship of Geology in the University, which had been held since 1788 by Professor Hailstone. It was remarked by the late Professor Phillips, F.R.S., that 'his attention to geology was speedily awakened, and became by

degrees a ruling motive for the long excursions, mostly on horseback, which the state of his health rendered necessary in the vacations. It was not, however, so much his actual acquirements in geology as the rare energy of his mind, and the habit of large thought and expanding views on natural phenomena, that marked him out as the fittest man in Cambridge to occupy the Woodwardian chair vacated by Hailstone. Special knowledge of rocks and fossils was not so much required as a well-trained and courageous intellect, equal to encounter theoretical difficulties and theological obstacles which then impeded the advance of geology.' For the long period of nearly fifty-three years he remained the honoured occupant of this Chair, relieved only during the last two years of his life, when his physical infirmities no longer enabled him to give his usual lectures, by Professor Morris, who in 1871 was appointed his deputy.

Professor Sedgwick's contributions to geology were numerous. They were mostly communicated to the Geological Society, the Cambridge Philosophical Society, or to the British Association. In the *Catalogue of Scientific Papers*, published by the Royal Society, thirty-nine memoirs are placed separately to his name; fourteen in conjunction with Sir Roderick Murchison, F.R.S., and two with Mr. W. Peile. His first acknowledged publication was read before the Cambridge Philosophical Society in 1820, on the physical structure of the Devonshire and Cornish formations, and it contained the record of his observations made in the preceding year. He was much interested in researches connected with the geological

formation of the south-western district of England; and as early as 1819 he saw clearly that the Plymouth fossil corals were not to be identified with those of the mountain limestone, but that they were of an earlier epoch. Fifteen years afterwards, Professor Sedgwick found a co-worker in Sir R. Murchison, in conjunction with whom he was again occupied in researches connected with the geology of Devonshire. At the meeting of the British Association held at Bristol in 1836, a joint paper was read on the carbonaceous strata between Dartmoor and the north-western coast of Devon, in which was pointed out for the first time the true geological position of the several deposits. In a subsequent memoir published in the *Transactions of the Geological Society*, these two great geologists gave a complete account of the district; and they not only attempted to describe the successive formations north of Dartmoor, but also to bring them into comparison with the formations which expand from the southern side of the Dartmoor granite to Start Point, and to the other headlands of the south coast of Devon. In 1838 the country north of Dartmoor was again surveyed by Professor Sedgwick, and in the following year he was engaged with Sir R. Murchison in adopting the final classification of the older sedimentary rocks of our two south-western counties.

Perhaps one of Professor Sedgwick's greatest works was his examination of the geological formation of North Wales, which was, however, the subject of an unfortunate controversy with his colleague Murchison. It appears that while Murchison was

actively working out the succession of the strata in Shropshire and the adjacent part of Wales, Sedgwick was examining the country from Snowdon to the Berwyn Hills, and establishing the true succession of the strata to which he gave the name of Cambrian. Murchison, however, considered that the strata on which he had been working, and to which he had assigned the name of Silurian, was identical with that to which Sedgwick had given the name of Cambrian. On the authority of Murchison, Sedgwick at first accepted this arrangement, but he afterwards found reason to return to his original opinion. Though it was generally understood by geologists that Professor Sedgwick was correct, Murchison continued to assert for some time the accuracy of his views, still claiming the upper Cambrian of Sedgwick as a portion of his own lower Silurian. Hence arose a sharp personal controversy between these two distinguished men, which in after years was much deplored by both. Professor Sedgwick, however, on his part was only anxious to clear his scientific reputation from any slur arising from an error for which he was not primarily responsible. Now that the two great geologists have been removed from us, it is but justice to the memory of Professor Sedgwick to allude to a subject which was the cause of much bitterness of feeling at the time, and to remark that his original opinions have been fully confirmed by subsequent examinations.

In 1851, the Council of the Geological Society awarded to Professor Sedgwick the Wollaston Palladium Medal 'for his original researches in develop-

ing the geological structure of the British Isles, of the Alps, and of the Rhenish Provinces.' Sir Charles Lyell, F.R.S., in presenting the medal, observed that 'it was impossible within the brief limits of a single speech to enumerate all the Professor's various labours; but he referred especially to his memoirs on the magnesian limestone of the north of England, on the trap-rocks of Durham and Cumberland; on the fossiliferous strata of the north of Scotland and of the Isle of Arran, on the mountains of Cumberland, of the adjacent lake district, and of North Wales, his essays on slaty cleavage, on the true age of the strata of Devon and Cornwall, and on the Alps, and the Rhenish Provinces, as worthy of all praise, and valuable contributions to the treasures of British science.'

It is not our purpose, in this very brief sketch of the labours of Professor Sedgwick, to enter into any detailed account of the various geological researches which occupied his attention during his long career; but we may truly remark, that no member of the University ever laboured to a greater degree than he did to elevate the character of Cambridge as a school for the natural sciences, especially of geology. The time, money, and talent which he expended on the formation of the Woodwardian Geological Museum can only be duly appreciated by a careful examination of the choice collections, which are not only noted for their excellence and rarity, but also for the perfect and systematic manner with which the specimens are arranged. To this storehouse of science he has himself contributed many thousands of rock specimens,

chiefly British, besides a valuable series of organic remains.

In April 1871 Professor Sedgwick resigned the active duties of his Chair, which he had so worthily filled for more than half a century, his increasing years and infirmities preventing that attention to his ordinary lectures, which he up to that time was accustomed to give. He, however, felt always interested in the scientific inquiries which were carried on around him, and he also derived much pleasure in occasionally corresponding with his college friends of former years. He was popular as a lecturer, for his style was energetic, philosophical, and clear; and, notwithstanding his great age, he was as remarkable for his humour and anecdote as when in middle age. It has been truly written of him that, 'for high moral courage, for honesty and singleness of purpose, for generosity of nature, and for a hatred for all that is mean and base, no name ever stood higher than that of Adam Sedgwick. Indeed, he was beloved by all who had the privilege of his friendship. In his declining years he had the satisfaction of feeling and knowing that he had not lived in vain, and that, besides lending a helping hand towards the elucidation and popularisation of geology as a science, he had been, during half a century of hard labour at Cambridge, the teacher and trainer of many first-rate practical geologists, several of whom had done their appointed tasks, and had passed away before him, to whom they looked up as their master.' [1]

[1] *Times*, January 28, 1873.

Professor Sedgwick became a Fellow of the Royal Astronomical Society in 1830, but he has never contributed either to the *Memoirs* or *Monthly Notices*. He was, however, none the less interested in astronomy, especially in former years, as those who have been intimately acquainted with him have frequently testified. He was one of the oldest surviving Fellows of the Royal Society, having been elected in 1821. He was also a Fellow of the Geological Society, and, having served on the Council, was elected to the Presidential Chair in the years 1829–30–31. Professor Sedgwick was in Holy Orders, and held a Canonry in the Cathedral Church of Norwich from 1834 till his death.

The Professor had been ailing some time before his illness became serious. During several weeks, however, before his death, his weakness had increased considerably, and he was in so precarious a condition all the time, that no hopes were entertained of his recovery. On the morning of January 27, 1873, he quietly passed away in the eighty-eighth year of his age, deeply regretted by the resident members of his University, with whom he had so long dwelt, and also by the scientific world, of which he was so bright an ornament during the greater portion of his life.

MISS ANNE SHEEPSHANKS.

1789–1876.

MISS ANNE SHEEPSHANKS was one of the many patrons of astronomy whose memory will remain associated with its history in the nineteenth century. The sister and companion of the late Rev. Richard Sheepshanks, F.R.S., of whom she was the senior by five years, she shared the interest which he always took in astronomical subjects, and especially in the proceedings of the Royal Astronomical Society, in the administration of which he had laboured faithfully and successfully to within a short period of his death. Through this admiration of her brother's love for astronomical work, and also as a record of her own affection for his memory, Miss Sheepshanks determined to devote a considerable portion of her property for the promotion of the study of his favourite science in the University of Cambridge. To carry out her views in the most advantageous manner, she sought the advice and assistance of some of her brother's most intimate scientific friends, by whom she was guided in her decision as to the appropriation of her intended gift. She ultimately resolved to transfer the munificent donation of £10,000 Consols into the joint names of the Master, Fellows, and Scholars of Trinity College and Mr. (now Sir George

B.) Airy, F.R.S., the interest of which was to be devoted to the advancement of astronomical and kindred sciences in the University. A Grace, accepting the gift, was passed by the Senate at the Congregation held on the 9th of December, 1858. It was finally recommended by Dr. Whewell, F.R.S., Master of Trinity College, and Mr. Airy, on the part of Miss Sheepshanks, and agreed to by the Vice-Chancellor and other University authorities, that one-sixth part of the amount, producing £50 per annum, should be specially devoted to the foundation of an astronomical scholarship at Trinity College, to be named the 'Sheepshanks Exhibition,' and that it should be open to the undergraduates of any of the colleges, the exhibition being awarded, after examination, to the candidate best versed in theoretical and practical astronomy. Bearing in mind the long connection of Mr. Sheepshanks with Trinity College as one of its Fellows, it was considered that the endowment of this permanent astronomical exhibition would be a most appropriate memorial to him in his own University, and at the same time be subject to the care of his own college. Though the Sheepshanks Exhibition is open to the whole University, it has been practically confined to Trinity College, and it has been generally given to one of its undergraduates, who subsequently attained the high position of Senior Wrangler. The first examination took place in 1859. The exhibition is tenable for three years, on condition that the holder shall keep, by residence, every University term during that time. The interest of the remaining five-sixths of the donation has been

reserved to be applied, as required, for the promotion of astronomy, terrestrial magnetism, and meteorology, in connection with the Cambridge Observatory, either in the payment of the stipends of the assistants and computers, or in the purchase of instruments.

In 1860, an additional sum of £2,000 was placed by Miss Sheepshanks into the hands of Mr. Airy to provide a fund for the purchase of a new transit-circle for the Cambridge Observatory. Circumstances having prevented the immediate erection of the instrument, Mr. Airy, with the donor's consent, transferred the amount, with its accumulated interest, to the Vice-Chancellor in the beginning of 1863, a Grace having passed the Senate for its acceptance on the 12th of March of that year. From this second act of beneficence on the part of Miss Sheepshanks, the Cambridge Observatory has been enriched by the excellent meridian-circle, which was constructed by Mr. James Simms, and mounted in the latter part of 1870. It is a first-class meridional instrument, and compares favourably with those at other public Observatories. It is furnished with an object-glass of eight inches aperture, and is provided with two graduated circles of three feet in diameter, one fixed and the other movable. It has also two collimating telescopes, as in the Greenwich transit-circle, each of six inches aperture, which can be directed on each other through the central cube of the instrument. In its construction generally, advantage has been taken of many recent improvements in this class of instruments.

Miss Sheepshanks, after the sudden death of her

brother in 1855, lived a very retired life at her residence at Reading, where she died on February 8, 1876, aged eighty-six years. The Fellows of the Royal Astronomical Society are greatly indebted to her representative, the Rev. Thomas Sheepshanks, for his spontaneous and valuable donation to their Library of 161 separate works, consisting of 192 volumes, forming a portion of the library of the late Rev. Richard Sheepshanks. Many of these works are extremely rare, and of considerable pecuniary value. The title of each work may be found in the list of presents attached to the supplementary number of vol. xxxvi. of the *Monthly Notices*. A box containing a large number of letters on scientific subjects, received by Mr. Sheepshanks from several distinguished astronomers, together with other correspondence on some controversial matters, has also been presented to the Society, at the request of the Secretaries.

LIEUTENANT-COLONEL A. STRANGE, F.R.S.

1818–1876.

LIEUTENANT-COLONEL ALEXANDER STRANGE, F.R.S., was born at Westminster on the 27th of April, 1818, and was the fourth son of Sir Thomas Strange. He received his principal education at Harrow. In 1834, at the early age of sixteen, he was appointed to the 7th Regiment of Madras Light Cavalry, and soon after left England for India, where he passed a continued service of twenty-six years, a large portion of which was in connection with the Great Trigonometrical Survey, then under the superintendence of Captain (afterwards Major-General Sir Andrew) Waugh, F.R.S. His abilities, which were of the highest order, attracted the attention of several scientific officers, from whom he received not only valuable counsel, but also practical instruction in the use of astronomical and surveying instruments. His mechanical skill, so advantageously utilised in after years in his designs for improved geodetical instruments, made it obvious to the military authorities that scientific employment was his natural avocation, and that his talents would prove more advantageous to the service if devoted to the scientific branch of the army than if they were permitted to remain

dormant in the routine performance of his regimental duty. For a time he studied at the Magnetic and Meteorological Observatory at Simla, then under the charge of Major (now Major-General) J. T. Boileau, F.R.S.; and in 1847 he received the appointment of Second Assistant in the Great Trigonometrical Survey, the duties of which exactly corresponded with his taste for astronomical observing. He thus obtained a full scope for the exercise of those peculiar talents for scientific work which he had exhibited from the time of his entry into the service.

Soon after the acquisition of Scinde and the Punjaub, the Surveyor-General considered it of great importance that the newly-acquired territory should be connected with the 'Great Arc Series' of triangulations, having the Dehra Doon base at the north, and the Sironj base at the south. From the base at Dehra Doon a north-western series was also proposed to be extended to near Attock, where a new base was to be measured. It was likewise resolved that the line of the 'Calcutta Longitudinal Series' should be extended from the Sironj base to Kurrachee, to be named the 'Great Longitudinal Series,' forming, with extensions to other districts of the Indian territory, a perfect gridiron of triangulations. The western section of this operation was commenced at the end of 1848 by Captain Renny (afterwards Major Renny-Tailyour), assisted by Captain Strange and others, commencing from the Sironj base. In the following year, Captain Renny retired from the Survey, after having executed about eighty miles of triangulation. He was succeeded by Captain Strange,

under whose superintendence this important geodetical work was brought to a successful termination. He was assisted by Lieutenant (now Colonel) Tennant, R.E., F.R.S., and a civilian staff. This triangulation was carried over the rugged range of the Aravulli mountains, then across the great Thurr, or desert, to the north of the Runn of Cutch. After crossing the valley of the Indus, the party reached Kurrachee in April 1853, after five seasons of very severe work. Some idea may be formed of the magnitude of this great triangulation by a reference to the actual distances between the commencing and terminal stations. It has been calculated that the series was 668 miles in length, and consisted of 173 principal triangles, covering an area of 20,323 miles. This is also the first example of a true desert being successfully traversed by a great triangulation.

The remarkable energy displayed by Captain Strange in the management of this great surveying work reflected on him the highest credit, and the manner in which the triangulation was effected was fully to the satisfaction of the Surveyor-General. How these field duties were performed by the party, and what obstacles they had to encounter, is thus related by Mr. Clements R. Markham, F.R.S., in his *Memoir on the Indian Surveys*, a work to which the author is indebted for several of the facts contained in this notice. 'The great difficulty, peculiar to this series, was the crossing of the desert. No geodesical operation of the first order had, at that time, ever been conducted in a desert, and experience was therefore totally at fault as to the probable obstacles to be

encountered. Stations had to be selected, in the first instance, by an advanced party. At each station a masonry platform had to be erected in a country entirely composed of sand, and destitute of building materials. After this had been accomplished, the main party engaged in taking the final observations, numbering two hundred men, had to be maintained in the desert during a whole season. The desert furnished only three things useful to man or beast, namely, grass, immediately after the rainy season; limited supplies of milk; and brackish, or, more correctly, salt water in deep wells, scattered at wide intervals. The arrangements, therefore, involved the supply of provisions of every description for two hundred men during several months, and also the distribution of these provisions to the numerous detachments into which the party was necessarily divided. For this purpose dépôts had to be established beforehand throughout the tract to be crossed. Special arrangements were also necessary for supplying the people with water from distant wells. Being favoured with good weather, and immunity from sickness, the final triangulation of the desert was completed in one season, 1851-2. . . . . Captain Strange's party having crossed the desert, they commenced operations in Scinde on December 8, 1852. The first station was Chortlee, where it was necessary to observe from a tower thirty-seven feet high, the side being twenty-two miles long, and crossed by the Indus. The view was obstructed by a dense *babool* jungle, intersected in many places by sheets of water. It was a tedious task to clear the line, and then it

was long before the signal could be made out at the other station of Helaya, twenty-two miles away. After a wearisome detention of twenty-five days, and much painful straining of the eyes, occasional faint glimpses of Helaya were caught, and at length the angle was satisfactorily observed. At the next station of Kanad there were fresh misfortunes. The tower, thirty-nine feet high, began to emit a crackling sound towards evening, and luckily the great theodolite had not been placed, when one of the angles fell in. At another place the great theodolite narrowly escaped destruction from a hurricane, and was rescued by the desperate efforts of its guardians, amidst the war of the tempest, in a night of inky darkness. Such are the sort of harassing difficulties and delays which form the daily life of the surveyor, but which are ever cheerfully faced and overcome. Captain Strange and his party had their full share; but at length their work was completed, and the last angle of the series was taken at Muggur Peer station on the 22nd of April 1853.'

From this time Captain Strange was employed continuously on surveying work, and in June 1854 he was promoted to the rank of Brevet-Major. In the winter of 1853–4 he assisted in the measurement of the base-line at Attock, the place previously selected by the Surveyor-General as the site for the northern base, in company with other chief officers in the Survey. At the conclusion of the measurement, the apparatus was transported to Kurrachee, the selected site for the southern base operations. The principal charge of this second measurement was entrusted to

Major Strange, under the general superintendence of Captain Waugh, the Surveyor-General, who joined the party at Kurrachee on December 6, 1854, on which day the measurement was commenced. It was finally completed on the 20th of the following month.

On the retirement, in 1855, of Mr. Peyton from the superintendence of the 'Eastern Coast Series,' Major Strange was appointed his successor. The surveying work of this 'Series' consisted in carrying a chain of triangles over the eastern coast of the Peninsula from Calcutta to Madras; and it proved to be one of the most difficult portions of the whole Survey, owing principally to the unhealthy climate, the general unfavourable state of the atmosphere, an inaccessible country, and, what probably gave the most anxiety, an inefficient native staff. The work was frequently interrupted by one or other of the party being laid low with jungle fever, which produces a great debility, and depression both of the mental and physical powers. In 1857 Major Strange had a very severe attack, which compelled him to retire temporarily, and to seek a more bracing climate for the restoration of his health, and for some time he resided at the Neilgherry Hills. On his recovery, he returned to his duties, and considerable progress was made in the Survey; when by his promotion in 1860 to the rank of Regimental Major, in accordance with the usual regulations of the Service, he was obliged to retire from the superintendence of the Series, and also from the Great Trigonometrical Survey, after a connection of thirteen years with the Department.

He was succeeded in the charge of the 'Eastern Coast Series' by the late Captain Basevi. In 1861 Major Strange returned to England, and soon after retired from the army with the rank of Lieutenant-Colonel.

The practical experience gained by Colonel Strange during his various surveying operations naturally rendered his opinion, in connection with the construction of scientific instruments, of great value; for his proved mechanical skill, and his practical knowledge of the use of mathematical, surveying, and astronomical instruments, were equalled by few men in this country. In 1862, the Indian Government, desirous of securing the advantages of so much experience in instrumental matters, entrusted to Colonel Strange the task of designing and of superintending the construction of a series of massive and standard instruments, of the first order, for the use of the Great Trigonometrical Survey of India, and in 1863 he received the appointment of Inspector of Scientific Instruments—his duty to consist of examining and testing every instrument purchased in England, and destined for public service in India. For this purpose an Observatory was erected at the warehouse of the Store Department of the India Office, in the Belvedere Road, Lambeth, where Colonel Strange's office was established. This Observatory was fitted up with great care, the foundation of the building resting on the underlying gravel, twenty-four feet below the surface of the London clay. This precaution was rendered necessary owing to its being exposed to a vibratory motion from its proximity to the London

and South Western Railway, and to the rest and complete isolation required in testing some of the most important of the astronomical and geodetical instruments. Those usually inspected under Colonel Strange's personal superintendence consisted principally of astronomical telescopes, sextants, theodolites, levelling instruments, barometers, thermometers, and almost every kind of mathematical and drawing instruments. Nearly one hundred different kinds have been examined yearly, and in that interval as many as 7,000 instruments, large and small, passed through his hands for service.

But the principal instrumental work which occupied the attention of Colonel Strange, was that required for the completion of the large surveying instruments ordered for the Indian Trigonometrical Survey. These consisted of two zenith-sectors and a great theodolite, by Troughton and Simms; two five-feet transit instruments, and two smaller ones, by Cooke; two twelve-inch vertical circles, by Repsold; two galvanic chronographs for the registration of transit observations, by Secretan; and three astronomical clocks, by Frodsham. The consideration of the best means of construction, of the metal to be employed, the preparation of the working drawings, and the preliminary trials of the different instruments, absorbed a considerable portion of the time devoted by Colonel Strange to his official work. All this was, however, performed without neglecting the general inspection of the smaller class of instruments. The working drawings of the great theodolite were completed as early as May 1862, embracing the most

minute details in nine large sheets, accompanied by a voluminous specification.

Colonel Strange joined the Royal Astronomical Society on April 12, 1861, and he was an active member of the Council, and Foreign Secretary, from 1863 to 1873. He was an ardent lover of science for its own sake; and from the date of his return from India till his death he was associated in the management of several Societies, whose objects coincided with his own peculiar habits of thought. He became a Fellow of the Royal Society on June 2, 1864, and was a member of the Council from 1867 to 1869. He was much interested in the Annual Meetings of the British Association, and was a frequent speaker and contributor in Section A. He was also connected with the Meteorological Society and the Society of Arts. Though Colonel Strange was so much occupied with his official work, he had sufficient leisure to enter heartily into any scheme which had for its object the advancement of any branch of science. Most of his communications to the Royal Astronomical Society have a highly practical value, and relate chiefly to improved methods of instrumental construction. They exhibit evidence of his great technical knowledge of the optician and engineer's workshops, and they all add to his reputation as a mechanician of the highest order. The following are the titles of his principal papers contained in the *Memoirs* and *Monthly Notices*:—*On Testing the Vertical Axis of Altazimuth Instruments; On a Direct Method of Testing and Adjusting the Equipoise of Altazimuth Instruments; On a Proposed Isolated Flange for Co-*

nical Axes; On Aluminium Bronze as a Material for the Construction of Astronomical and other Philosophical Instruments; On a Zenith Sector for the use of the Trigonometrical Survey of India, &c. In his observatory at Lambeth, Colonel Strange was frequently occupied in purely astronomical work—principally, however, with the object of proving the capabilities of his instruments. In consequence of the peculiar, and, to some extent, private, nature of the observations, very few of them have been published, although some might have been to the advantage of astronomy. He was known to have made a careful determination of the latitude of his Observatory with one of the instruments made for the Indian Survey; and the observations, if judged by the accordance of the separate results submitted to the author for his inspection, must have been of great excellence.

Colonel Strange was requested to perform the duties of a juror in the International Exhibition of 1862. He undertook this important office with much pleasure, as it was one in which he could bring his practical knowledge to bear on the peculiarities in the construction of the numerous scientific instruments which came under examination. He served also a similar office in the Paris International Exhibition of 1867. He had very decided opinions on the question of Government endowment of scientific research; but though they were considered by many as somewhat impracticable, yet very few can doubt his own great sincerity in the soundness of the views entertained by him on the subject. The appointment by her Majesty of the 'Royal Commission on Scientific Instruction

and the Advancement of Science,' of which the Duke of Devonshire was Chairman, was, in a great measure, the result of his persistent advocacy of the necessity for increased Government aid for the promotion of scientific research; and, before his death, he had the satisfaction of knowing that many of his proposals were adopted by the Commission, and recommended to the Government for their consideration. Some of them have since been carried out to the advantage of science.

The health of Colonel Strange was not good for several months before the end came; but the announcement of his death was unexpected, and was received with deep regret by a large circle of scientific friends. He died at the residence of his niece in Onslow Square, London, on March 9, 1876, at the comparatively early age of fifty-seven.

MAJOR-GENERAL SIR ANDREW SCOTT WAUGH, F.R.S.

1810–1878.

SIR ANDREW SCOTT WAUGH, Knt., R.E., F.R.S., was the eldest son of General Gilbert Waugh, Military Auditor-General of Madras, and grandson of Colonel Gilbert Waugh, of Gracemount, Midlothian. He was born in the year 1810, and educated first at the High School of Edinburgh, and afterwards at the Military College at Addiscombe, which he left in 1827 as head mathematician. In the same year he entered the Bengal Engineers as Second Lieutenant, and in a few months he was promoted to the rank of First Lieutenant. The first two years of his army service were spent in the ordinary duties of the corps; but in 1829 he was made garrison engineer at Allahabad, and in 1830 Assistant in the Gun Foundry, and Adjutant in the Bengal Engineers. On July 2, 1832, he was appointed on the staff of the Great Trigonometrical Survey of India, then under the superintendence of Colonel (afterwards Sir George) Everest, F.R.S., and he soon became one of the most energetic of the assistant-surveyors. After a short preliminary training, Lieutenant Waugh, in company with his friend Lieutenant Renny, was entrusted with the exploration of a difficult jungle district between Chunar

and the sources of the Son and Narbada, up to Jabalpore. This survey was successfully performed; and a manuscript volume prepared by these two young officers, containing detailed particulars of the route, is still preserved in the geographical department of the India Office.

Soon after Lieutenant Waugh joined the Survey, Colonel Everest resolved to resume the work connected with the Meridional Arc Series. This portion of the triangulation had hitherto been conducted over the elevated plateau of the Deccan, but had been suspended for a time. In entering upon this renewed work, he was most zealously assisted by his young colleagues, Waugh and Renny, and the ultimate success of the operations was in a great measure due to the skill of these enterprising officers. At the end of 1834, the work of measuring the most northern base of this Great Arc Series in the valley of the Dehra Doon was commenced. This station is situated 2,000 feet above the level of the sea, between the Siwalik hills and the Himalayas. In all this delicate work Lieutenant Waugh took an active part. A few years later, in October 1838, he commenced the revision of the observed angles in the Deccan with a large theodolite by Troughton; and some idea of the extent of this work may be obtained, when we consider that before his return to Dehra Doon in June 1839, he had traversed over a meridional distance of 260 miles. In this manner he continued fully occupied as a most active and trusted assistant during the few remaining years of the superintendence of Colonel Everest, who returned to England in 1843.

On the retirement of Colonel Everest, Captain Waugh was chosen to succeed him as Superintendent of the Trigonometrical Survey, and Surveyor-General of India, chiefly on the recommendation of his late chief, who thus wrote of his qualifications:—'He is beloved and respected by all the subordinate members of my department, and held in honour and esteem by all who know him personally. His talents, acquirements, and habits of a scholar, a mathematician, a gentleman, and a soldier, are of a high order.'[1] No sooner was Captain Waugh's appointment confirmed than he resolved to carry out, as far as was possible, the plans of his predecessor and friend. His first object, therefore, was to complete the 'gridiron,' two parallel sides of which were formed by the Great Arc, and a Calcutta Meridional Series; and the remaining two by a Calcutta Longitudinal Series, and another passing along the base of the Himalayas; the 'grating' being formed by ten meridional series at distances of sixty miles, beginning at the Calcutta Longitudinal and ending in the Himalayan Series. This extensive system of triangulations was completed in 1850; and during the operations special attention was given to fixing the altitudes of seventy-nine of the Himalayan peaks, the highest of which, 29,002 feet above the level of the sea, was named Mount Everest, in honour of the late Superintendent. All this surveying work was carried on generally under considerable privations, and often with danger from various causes. Many of those employed lost their lives by wild animals or by

[1] *Memoir of the Indian Surveys*, by C. R. Markham, F.R.S.

jungle fever, and this without respect to rank in the service. Of the five officers who successively had the personal charge of the North Western Himalayan series, two retired in impaired health, and two fell victims to the climate.

From this time till his retirement, Captain Waugh was continuously engaged in similar operations, some of which he personally superintended. He was fortunately assisted by a noble band of officers, competent to carry out his instructions with intelligence and zeal; among whom we may mention the names of Shortrede, Renny, Strange, Walker, Montgomerie, Tennant, Peyton, and others, all gifted men of science. By the annexation of Scinde, in 1843, a new field was opened for surveying operations, and the importance of an early survey of the newly-acquired territory was at once acknowledged by the Government. Captain Waugh therefore, as soon as his party could be spared for the purpose, devised a system of triangulation of the whole country, which was commenced in 1847. In connection with these operations, he, in 1853–4, took much interest in the observations for the measurement of the Chuch base, near Attock in the Punjaub, and, subsequently, of the Kurrachee base. The latter was undertaken, chiefly by Captain Strange, assisted by Lieutenants Montgomerie, Tennant, and Nasmyth, but under the general supervision of Captain Waugh, who has given in a manuscript volume, preserved also at the India Office, the details of the observations and methods employed, which are most valuable instructions and suggestions for every conceivable emergency. The measurement of the Kurrachee base

occupied more than six weeks, and it was completed on January 20, 1855. A series of levelling operations was instituted in the Indus valley by Colonel Waugh in 1858; and before his retirement in March 1861, he sanctioned the preliminaries for the surveys of Cashmere and Scinde Sagar Doab.

In 1860 Colonel Waugh received the honour of knighthood, and in 1861 he was promoted to the rank of Major-General. For a short time previously he served as Commandant of the Royal Bengal Engineers. The dates of his successive army promotions are:—Captain in 1842, Major in 1855, Lieutenant-Colonel in 1857, and Colonel and Major-General in 1861. He received the thanks of the Government on several occasions for his distinguished scientific services; and, as a mark of the respect felt towards him by his subordinates, the whole staff, consisting of 191 persons, presented him with a valuable piece of plate in 1862. On his return to England, Sir Andrew Waugh associated himself with several of the leading scientific Societies. In 1857 he became a Fellow of the Royal Geographical Society, on whose Council he served from 1861 to 1872, and as a Vice-President from 1872 to 1877. In 1858 he was elected a Fellow of the Royal Society, and in 1867 of the Royal Astronomical Society. He was also a genial and much esteemed member of the Geographical and Astronomical Clubs. He was a Gold Medallist of the Royal Geographical Society in 1858. Sir Andrew was an honorary member of several foreign societies, and he was a Commissioner of Lieutenancy for the City of London.

Sir Andrew Waugh was twice married, first in 1844 to Josephine, daughter of Dr. William Graham, of Edinburgh; and secondly, in 1870, to Cecilia Eliza Adelaide, third daughter of Lieutenant-General Sir Thomas Whitehead, K.C.B., of Uplands Hall, Lancashire, who survives him. He died at his residence, 7 Petersham Terrace, Kensington, on February 21, 1878, at the age of sixty-eight, leaving a son by his first marriage, now a Lieutenant in the 78th Highlanders.

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